JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HYDROLOGY AND HYDRAULIC ENGINEERING CHAIR

ASSESSMENT OF FACTORS AFFECTING SUSTAINABILITY OF RURAL WATER SUPPLY SCHEMES: A CASE STUDY OF LARE DISTRICT, GAMBELLA REGION, ETHIOPIA

BY

REAT RIAL LIEM

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN HYDRAULIC ENGINEERING.

AUGUST, 2021

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MAJOR ADVISOR: Dr. Ing. TAMENE ADUGNA (PhD)

CO-ADVISOR: SEWMEHON SISAY (M.Sc.)

AUGUST, 2021

JIMMA, ETHIOPIA

DECLARATION

I, the under signed, declare that this thesis: Assessment of Factors Affecting Sustainability of Rural Water Supply Schemes: A Case Study of Lare District, Gambella Region, Ethiopia is my original work, and it has not been presented for a degree in Jimma University or any other University and that all sources of materials used for the thesis have been fully acknowledged.

Name	Signature	Date
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This Thesis has been submitted for examination with my approval as University Supervisor.

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ABSTRACT

Scheme sustainability is when water supply service is functioning, being used and is able to deliver an appropriate level of service in terms of quality, quantity, convenience, continuity and health to all. Having Sustainable Rural Water Supply schemes is so vital to sustain life for people living in the rural areas and their livestock. However, there is a problem of water sustainability in Lare district and there are factors that cause that problem. These different factors in the district affect water supply schemes for not being sustainable. This research gave an insight for local studies and investigations to understand how the rural water supply schemes of the study area perform under the local condition of planning, implementation, operation, maintenance and management. Therefore, the main objective of this study is to identify factors that affect the sustainability of rural water supply schemes since there are limited data available on water supply schemes sustainability in Lare district. Both quantitative and qualitative data gathering methods were carried out. Primary data were collected through questionnaire, observation, and structured interview like key informant interviews (KII) and focus group discussions (FGD). In selecting of respondents from Lare district's Kebeles, Purposive Sampling Technique was used, and in selecting Villages and Rural water supply schemes, Probably Stratified Sampling Method was used since the Rural Kebeles were characterized by the same cultural settings and socio-economic conditions. Data were edited and coded before analysis then for analysis of data that were collected; both descriptive and inferential data analysis had been used. The quantitative data which were generated from household surveys were analyzed using descriptive statistical tools such as standard deviation, mean, frequency/percentage and Pearson's correlation. They were operated with Statistical Package for Social Science (SPSS) and Microsoft Excel. The result was represented by tables, graphs and charts, and the word part was digested in narrative form. The finding indicated that 62.9% of respondents said there was an environmental problems due to flooding of the area during rainy season, 61.6% showed that there was lack of finance for operation and maintenance, 56% was due to lack of provision of spare parts and 65.7% was due to lack of local technicians. But according to AHP method, the dominant factor was technical factor followed by environmental factor. Stakeholders do not participate equally during planning of projects and some of stakeholders do not participate in all phases of projects. From functionality of rural water supply, the distance travelled to get drinking water was met by 23% of the population and the time taken on queue was met by 22% of the people living in the study area according to UAP for the year 2016-2020 G.C. The Pearson's correlation between the number of jerry cans fetched and the amount of Birr paid have a statistically linear relationship with $r=0.630$ and $p<0.001$, the direction of their relationship is positively correlated and they do have strong correlation. The result has shown that there were problems on environmental, technical, financial, contribution of stakeholders and functionality of rural water supply. This problem needs further study to tackle the real situation of this District.

Key Words: *Affecting Factors, Lare district, Rural Water Supply Schemes, SPSS, Sustainability*

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ACRONYMS

ADF	Africa Development Fund
CSA	Central Statistic Agency
ESA	Ethiopians Statistic Authority
FGD	Focus Group Discussion
GIS	Geographical Information System
GTP	Growth and Transformation Plan
IMF	International Monetary Fund
IWRM	Integrated Water Resources Management
KII	Key Informant Interview
Km^2	Square Kilo Meter
l/c/d	Liter per capita per day
MDG	Millennium Development Goal
MoWR	Ministry of Water Resources
NGOs	None Governmental Organizations
NWRMP	National Water Resources Management Policy
O & M	Operation and Maintenance
PRSP	Poverty Reduction Strategic Plan
RPS	Rural Piped System
RWSS	Rural Water Supply and Sanitation Services
SPSS	Statistical Package for Social Science
UAP	Universal Access Program
UK	United Kingdom

UNICEF	United Nation International Children's Emergency Fund
USA	United States of America
VLOM	Village-Level Operation and Maintenance
WCED	World Commission and Environmental Development
WHO	World Health Organization
WBRR	World Bank of Regional Report

1. INTRODUCTION

1.1 Background

The availability of water to sustain life is important for every living thing. As well as access to clean and potable water is the basic and undeniable right for humans since water is vital for life (Frison et al., 2018).The right to water and sanitation is recognized in international legal instruments.

In fact people around the globe face serious problem of water scarcity due to different factors. Providing sustainable potable water supply systems for rural areas in resources-limited nations remains at the forefront of national and international agenda (Jones et al., 2012).

According to WHO reports in 2008, approximately 884 million people around the globe lacked access to improved water sources. Unfortunately, these figures cover the extent to which these problems affect rural areas; 84 percent of people lacking potable drinking water in rural areas (Jones et al., 2012).

In the same manner, in Africa also around 300 million people have no access to safe drinking water (Habtamu, 2012). The majority of rural areas in South Africa are experiencing the challenges of accessing water services because they cannot afford to pay for municipal services.

Similar to many African countries, Ethiopia encounters water shortages and lack of access to clean water sources. Hence, the Government has given the priority to expand the coverage of potable water supply in rural as well as urban areas. For this reason, huge amounts of fund from regional and national governments as well as local and international NGOs have been flowing to rural areas of the country to reduce the inaccessibility of rural community to potable water (Zemenu, 2012). Due to this, a number of portable water projects have been constructed in many parts of the country in the villages.

However, half of the boreholes and hand dug wells are not functioning which implies that much work should be done to increase the capacity of each community on operation and

maintenance (Selamawit, 2007). Therefore, factors affecting sustainability of rural water supply of Lare district needs to be study. These lead this study to be conducted in Gambella Region particularly Lare district.

As sustainability could be defined in different forms by (Brikké and Bredero, 2003) which summarized the water supply service sustainability as the followings, if: It is functioning and being used; it is able to deliver an appropriate level of service in terms of quality, quantity, convenience, continuity and health to all; The management of service involves the community implying that the community has full involvement in its operation, maintenance, rehabilitation, replacement and administration costs that are covered by the community through user fees or other financing mechanisms;

It can be operated and maintained at local level with limited external support; and it adopts a perspective that addresses gender issues; it accounts for environmental issues and negative spillover.

Thus, sustainability of rural water supply schemes is important for existing of rural community, and the study needs to be conducted in Gambella Region as it was researched in other Regions. Having data for factors affecting sustainability of rural water supply schemes is essential for alleviation of people's problem. This study was conducted to serve as a preliminary study to assess factors affecting sustainability of rural water supply schemes of Lare district, Gambella Region.

1.2 Statement of the Problem

In some parts of the World through the study in accelerating Sustainable Water Services Delivery, a number of factors affecting relation to water services were identified for both Water Supply Affairs and Water Services Providers. Challenges identified in the selected villages included the availability of water sources, administrative challenges, issues that relate to policy and political interference. For many rural communities water sources and infrastructure are available, but not maintained, as a result becomes unusable and thus non operational (Mothetha et al., 2013).

The majority of rural areas in South Africa are experiencing the challenges of accessing water services because they cannot afford to pay for municipal services. It is also acknowledged that most municipalities predominately serving rural communities face a number of challenges in supplying these communities with at least basic level of service (Mema, 2013).

In Ethiopia, provision of efficient, reliable and acceptable drinking water supply services to rural and urban population has become the major concern (MoWR, 2007). However, 33% of rural water services in Ethiopia are non-functional due to lack of funds for operation and maintenance, inadequate community mobilization and commitment, less community participation in decision making as well as lack of spare parts (ADF, 2005).

In Amhara Region during WASH 2013 inventory report, 25% of rural water supply schemes were non functional (Tigist, 2014). There are some studies which have been done in other areas of Africa; like South Africa and high Land Regions of Ethiopia about factors affecting sustainability of rural water supply schemes.

In the same way Lare district has the same problem as other districts of Ethiopia and other parts of Africa in general that needed to be study.

In the light of the above findings, it is shown that there are problems that let rural water supply schemes not to be sustainable. Therefore, the researcher was assessing the factors that affected the sustainability of rural water supply schemes since there was limited data available on water service sustainability in Lare district, Gambella Region.

Five key factors were studied; they are technical factors, community factors, financial factors, institutional factors and environmental factors, as well as stakeholders' contribution and schemes functionality factors.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study is to assess factors that affect the sustainability of rural water supply schemes in Lare District.

1.3.2 Specific Objectives

- To assess financial, technical, institutional, community and environmental factors sustainability on rural water supply of Lare District.
- To explore the stakeholders' contribution on sustainability of rural water supply schemes of Lare district.
- To determine the factors that affect rural water supply schemes functionality of the study area.

1.4 Research Questions

1. Are rural water supply schemes of Lare district sustainable?
2. Is there any contribution from the stakeholders (Community, NGOs or Government Institutions or Sectors) on sustainability of rural water supply schemes in the study area?
3. What are the indicators for water supply schemes functionality and sustainability in Lare?

1.5 Significance of the Study

For developing countries such as Ethiopia where there is a problem of safe and adequate water to fulfill the needs of the population, research on assessing the factors affecting sustainability of rural water supply schemes is vital.

This research will give an insight for local studies and investigations to understand how the rural water supply schemes of the study area perform under the local condition of planning, implementation, operation, maintenance and management. This study will serve as a reference for rural Water Supply Desks in Gambella Region. It will contribute toward awareness creation among sectors or institutions, community and NGOs which are the key stakeholders about the requirements needed to address the problems of rural water supply schemes. It will also serve as the baseline for other researchers who will be interested in doing researches in this study area.

1.6 Scope of the Study

The scope of this study focused on assessment of factors affecting sustainability of rural water supply of particular district, Lare. This research was primarily focusing on assessment of community aspect, technical aspects, economical aspects, institutional aspects, environmental aspects, stakeholders' contribution and schemes functionality factors on rural water supply schemes. This study does not include the effect of hydraulic and structural performance on rural water supply sustainability, ground water capacity and sustainability.

1.7 Limitation of the Study

In this study, the main problem faced was the lack of documents to get real information in the study area that might be due to poor handling of documents by the district Water Desk. There was pandemic disease/Covid-19 which limited the works on the fields and offices during data collection. Also there was no previous research done on rural water supply to see parameters and to compare my study with the previous one in the study area.

2. LITERATURE REVIEW

2.1 Overview of Sustainability

2.1.1 Sustainability in Rural Water Supply System

Sustainable rural water supply is defined as one in which the water source are not over exploited but naturally replenished, facilities are maintained in a functional state which also ensures a reliable and adequate water supply and also benefits of the supply continue to be realized by all users over a prolonged period of time. Enabling rural water supply schemes to remain operational over the design period requires a number of complex and interrelated technical, social, environmental, financial and managerial issues up on which failures in meeting any of these can lead to failures of schemes (Abrams, 2013). The same source pointed out that "if the water flows" then all of the many elements which are required for sustainability must have been in place.

There is a broad range of definitions of sustainability in RWSS used in different studies. The majority of these definitions are similar in nature but have slight differences in emphasis. There also exist a number of definitions that are significantly different. How we define sustainability is important for selecting parameters, which are then important for measuring and understanding the determinant factors that affect prospects of sustainability.

As (Amjad et al., 2015) notes, there arises a problem for objective quantification of sustainability because the adjective "sustainable" has strong normative connotations. That is to say that different group of people, users of water, donors, national governments, local private sector companies, research institutions, etc. have different perceptions of sustainability based on the relative value attached to its achievements (Zemenu, 2012).

Different organizations may choose to use sustainability from different angle, like technical performances, empowerments, social equity or the environment. Sustainability of rural water supply schemes refers to whether or not the schemes continue to function over time. It also refers to the provision of safe, adequate, water supply facilities at reasonable costs on long-term basis. It is evaluated on different dimensions such as, the extent to

which the new scheme continues to supply at the same rate the quantity needs as planned at the beginning and the environmental aspect of the supply continues to be improved (Mengesha et al., 2002).

2.2 Assessment of the Factors Affecting Sustainability of Rural Water Supply Schemes

Several factors undermine the sustainability of improved water supply and sanitation services. Sustainability of rural water supply and sanitation services is a complex issue that depends upon many interrelated factors. Institutional arrangement, community engagement, technology choice, operation and maintenance costs, poor construction, financial and economic issues, spare-part supply and monitoring systems are among the factors that are crucial for ensuring the sustainability of rural water supply and sanitation projects (Harvey and Reed, 2007).

In addition, the sustainability of RWSS is also affected by natural and environmental factors such as recurrent drought coupled with erratic rain fall and reduction of ground water sources. Thus, the dimensions of sustainability of water supply schemes and its service delivery are multifaceted. There are five key sustainability areas such as technical, social, financial, institutional and environmental factors to address (Brikké and Bredero, 2003).

2.2.1 Technical Factors

This includes aspects related to sitting, design, and construction of water systems for withdrawal and delivery of water to users. It refers to the reliable and correct functioning of the technology and for water supplies to delivery enough water of an acceptable quality. Important dimensions of technical factors in include: technology selection and complexity of the technology; technical capacity of the system to respond to demand and provide the desired service level; a technical good design; technical skill needed to operate and maintain the system; the availability, accessibility and cost of spare parts; and the overall costs of operation and maintenance (ibid, 2003).

2.2.2 Social/Community Factors

Social factors focus on relationships and network between individuals and communities. Under these factors vital aspects include: demand for an improved water supply and sanitation service; community participation in all project phases; the capacity and willingness to pay; management through a locally organized and recognized group; financial and administrative capacity of management; socio-cultural aspects related to water and individual, domestic and collective behavior regarding the links between health, water hygiene and sanitation (ibid, 2003).

2.2.3 Financial Factors

This relates to aspects of financial resources from various sources to meet all costs for long-term viability without undermining social development goals, such as poverty reduction. Systems can only function if financial resources meet at least the costs of operation, maintenance and common repairs. Equity elements related to who pays for all these and how fairly payments are shared between and within the households (ibid, 2003).

2.2.4. Institutional Factors

Institutional determinants or factors refer to formal and informal rules and structures governing the management of water supply schemes. According to (Wallace et al., 2008) in any institution a need of different disciplines such as engineering, health, natural science and social science are essential, from the institution, and different sector, to achieve the plan and goal of the institution and solve environmental water and health problems.

2.2.5 Environmental Factors

This includes the availability and quality across time and space of the water resource itself, linked to characteristics that affect the supply and its sustainability. The following are major issues to be considered under these factors: quality of the water source (this will determine whether the water needs to be treated and will influence the technology choice); adequate protection of the water source or point; the quantity of water and continuity of supply and impact of wastewater or excreta disposal on the environment. In dry areas, lack

of drainage of wastewater has created new risks of insect breeding that have brought outbreaks of malaria, dengue and filariasis (Brikké and Bredero, 2003).

2.3 Indicators of Functionality

Functionality according to four Indicators when (SNV, 2013).

- Assessed against standard of drinking water
  - ✓ Quality
- Volume of drinking water used per person per day
  - ✓ Quantity
- Distance or time needed to reach, queue, collect and return with water
  - ✓ Accessibility
- Consistence or suitability of measurement of water quality
  - ✓ Reliability

2.4 Policies and Strategies Affecting Water Supply Sustainability

There is a wide range of government policies and strategies which affect rural water supplies, some directly and others indirectly. Many of these have significant impact on the sustainability of water services, intentionally or unintentionally. General national policies influence sustainability. Many African countries have developed similar generic policies primarily due to the influence of the IMF and World Bank (World Bank, 2001).

The (World Bank, 2016) aims to help policy-makers and sector departments to design Poverty Reduction Strategic Plan (PRSP), water and sanitation strategies that actively address the needs of the poor. The approach used is to provide guidance on analysis of the linkages between poverty, water and sanitation, to assist in identifying problem areas that require intervention and in defining objectives; Provide a menu of possible public interventions, and a framework that assists in their prioritization; and to assist in defining a monitoring and evaluation framework that allows reevaluation of the linkages, appraisal of poverty outcomes, and assessment of whether the chosen intervention has been effective.

Sustainability of rural water supply has a number of positive effects on poverty reduction, such as reducing the burden of disease and money spent on medical treatment; releasing

time previously used for collecting water for other activities; and facilitating income generation through productive use of water. Where existing policy and strategy papers fail to emphasize these links, advocacy campaigns may be necessary to highlight the need to incorporate rural water supply strategies into national PRSPs.

2.5 Rural Water Supply Strategies

Current strategies from different African countries are typified by the following: The setting of minimum quantities of water per person per day; Water sector reforms that define water as an economic good and adopt an integrated approach to delivering water and sanitation services; A decentralized approach to service delivery in which the role of the public sector at all levels is mainly to monitor, regulate and facilitate the performance of stakeholders in O & M; A demand responsive approach to the delivery of community based water supplies, for which users are responsible for managing O and M to ensure sustainability; Appropriate technology and research activities (Selamawit, 2007)

Many national strategies are influenced by external donors and international organizations, and hence there is a significant degree of uniformity of policy among different countries, at least on paper. As a result, despite local differences in culture, environment and politics, many effects of policy and strategy are region, rather than country, specific.

Table 2.1: Water Supply Service Level Ladder

Sr.No.	Service level	Water quantity (l/c/d)	Water fetching travel time (minutes)
1	Higher	60 liter and above	Below 10 minutes
2	Medium	40-60 liter	10-30 minutes
3	For basic sanitation	20-40 liter	30-60 minutes
4	Below standard	5-20 liter	Above 60 minutes
5	Not considered as service delivered	Below 5 liter	

Moriarty et al., 2011

2.6 Ethiopian Water Resources Management Policy

Water supply and sanitation coverage in Ethiopia is among the lowest of all developing countries and even of most countries in sub-Saharan Africa. The country water supply sub-sector has encountered a number of challenges throughout its development (MoWR, 2007).

Some of the factors that have affected the development process of the water supply sub-sector are as follows (MoWR, 2006):Water supply has not been reliable and sustainable; Water use has not been efficient; Programs and projects have not been objective-oriented; Plans have not been certain and clear; Water schemes have lacked a focus on good O and M of services; Integrated water supply and sanitation services have not been achieved; and There has been a lack of understanding that water demand includes livestock.

It has been estimated that 33% of rural water supply schemes in Ethiopia are nonfunctional at any time, owing to lack of funds for O and M, inadequate community mobilization and commitment and a lack of spare parts (ibid, 2007). With regard to this issue, the UAP aims to rehabilitate and maintain existing water supply schemes in the first two years of its seven-year plan, so as to develop a maintenance culture and increase the sustainability of both the newly constructed and the existing water supply schemes (MoWR, 2006).

Moreover, the policy stresses that water resources management has to integrate the development goals of other sectors, such as health and agriculture. The policy follows the principle that the water supply sector has to ensure that every Ethiopian citizen has access to water of acceptable quality to satisfy their basic human needs. The government later adopted the UAP to scale up the water supply and sanitation coverage of the country and achieve 100% water supply coverage in most of the rural regions by 2012 (MoWR, 2006). This includes the Lare district.

To improve this situation, the international community adopted the Millennium Development Goal (MDG) and committed to reduce by half the proportion of people without sustainable access to safe water and basic sanitation by 2015. As the main development objective of the Ethiopian Government is poverty eradication, the country's development policies and strategies are geared towards this end.

The provision of safe and adequate water supply for the population has far reaching effects on health, productivity, quality of life, and at large to reduce poverty and ensure sustainable socio-economic development.

In 2005 the government of Ethiopia has ratified Universal Access Program (UAP) that enables to provide safe water to all citizens of the nation. In addition, the first Growth and Transformation Plan (GTP-1) covering the period from 2011 to 2015 was also endorsed in 2010 and it is under implementation now.

This plan targets to increase the rural, urban and total access to water supply coverage to 98%, 100% and 98.5% respectively and reduce the malfunctioning schemes from 20% to 10%. For the last four GTP years (2011-2014) different activities has been implemented to reach the target, accordingly in June 2014 the water supply access coverage has reached to 75.5%, 84.1% and 76.7% in urban, rural, and national respectively.

As the first growth and transformation plan was finalized in the mid of 2015 this Second Growth and Transformation Plan (GTP-2) covering the period from 2016-2020 is prepared. As the country has a vision to reach to a level of lower middle income country in its socio-economic development by the year 2025, the plan is prepared taking into consideration this national vision.

Hence, the main focus of the plan is to ensure availability of water supply and sanitation services that satisfies the need of lower middle income countries' citizens by the year 2020.

For this purpose the experiences of some middle income countries such as Indonesia, Vietnam, Ghana, and Kenya which have some similarities to our country in demography, population settlement patterns, etc is reviewed and their best experiences and achievements are used to set the objective of the plan.

To attain this target, the UAP assumes that to make water supply schemes sustainable, hand pumps have to be made locally and repaired by local technicians and, generally, pumps and generators have to be standardized in relation to village-level operation and maintenance (VLOM) for sustainable service.

So every research needs to be compare whether it meets the universal target of providing access to safe and sustainable water supply for all citizens of the country in the planning period as per the minimum water supply access standard level set for GTP-1, i.e. for rural water supply 15 l/c/day within a distance up to 1.5 km and for urban water supply 20 liter per capita/day within a distance up to 0.5 km.

Provide rural water supply access with GTP-2 minimum service level of 25 l/c/day within a distance of 1 km from the water delivery point for 85% of the rural population of which 20% are provided with RPS and 30 minutes round trip including queuing time.

In the study area, lack of proper maintenance, management, and having unprotected water sources are big challenges. The factors affecting sustainability of rural water supply schemes in Lare district are not addressed. This should be the core issue of selecting this study area to understand the important factors affecting sustainability of rural water supply in Lare district.

3. MATERIALS AND METHODS

3.1 Description of Study Area

Lare is one of the districts in the Gambella Region of Ethiopia. It is part of Nuer Zone which covers total area of 685.17 km^2 with a population size of 31,406, of whom 16,145 are men and 15,261 women; it has 5,432 households which results in an average of 5.8 persons per household (CSA, 2007). Kuergeng is the main town of Lare district that is found 76 km away from Regional capital, Gambella. Lare is located in Western part of Gambella Town which is 766 km away from Ethiopia capital city, Addis Ababa, in western part of Ethiopia. The district lies between 8°11′0″ and 8°31′0″ North latitudes; and 33°50′0″ and 34°0′0″East longitudes. It has 28 Kebeles, 2 Kebeles in the main town Kuergeng, and the other 26 kebeles in the rural area. The study area map which was drawn by GIS is given below.

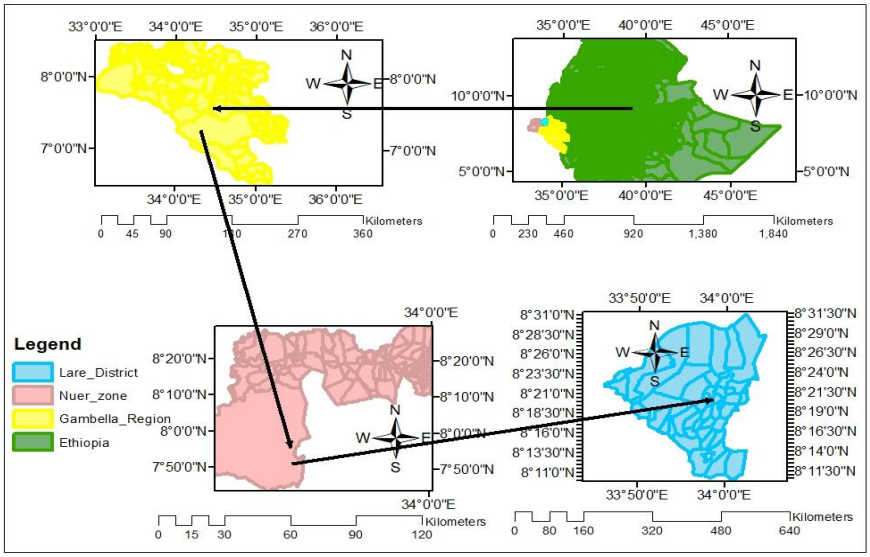


Figure 3.1: Map of the Study Area

3.1.1 Population

According to (CSA, 2007), Lare district had a total population of 31,406 which was forecasted to be 51,367 people in the year 2019 by the method used by Ethiopians Statistic Authority (ESA) with the annual growth rate of 4.1%.

3.1.2 Climate and Topography

The climatic condition of the area is so hot throughout the year with temperature that rises during summer, up to 45℃ in March; and in August, during the rainy season, it reaches 27-31℃, the mean annual temperature is 27.6℃; and its mean annual rainfall is 1148mm. the terrain in Lare consists of marshes and grasslands; elevations range from 410 to 430m above sea level (Gambella Water and Irrigation Resources Development Bureau).

3.2 Research Design

In this study both quantitative and qualitative data collection instruments were used in order to obtain primary data. Rural water supply schemes sustainability data were collected through questionnaire, field observation and structured interview. Quantitative data were collected through questionnaire and qualitative data were collected by employing structured interview and field observation data collection methods as annexed in (Annex 1, 2, 3 and 4). Purposive sampling technique was also used to choose respondents from the district and probably stratified sampling method was employed to select district's villages as indicated in (Annex 6 and 11). A simplified design of the study is schematically presented in (Figure 3.2).

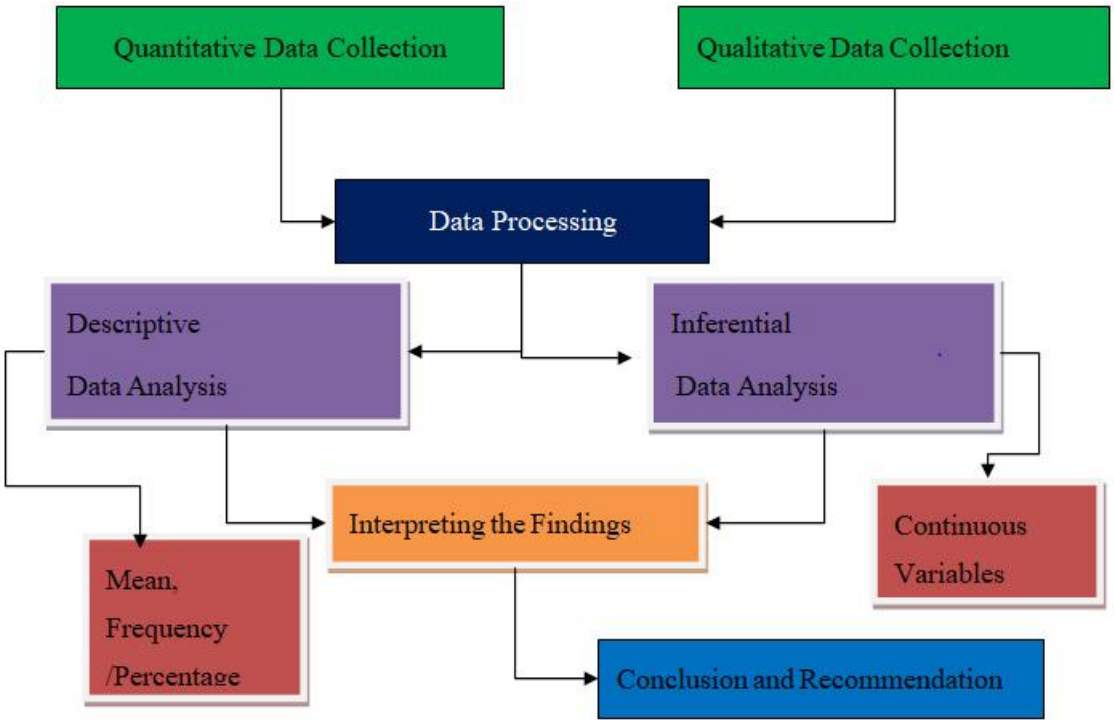


Figure 3.2: Flowchart for Research Design

3.3 Sample Size and Sampling Techniques

3.3.1 Sampling Size

According different methods for sample size determination, the one which was developed by Carvalho 1984, was used for sample size selection for this research. Taking the sample size of the Lare district with the population of 51,367 and since the researcher would not take the whole population for sampling; the target population was the people having knowledge of what the researcher was requiring. Then 20% of 51,367 that is 10,273 people who have knowledge of data that the researcher was collecting were considered as a target population.

Therefore, 10,273 population lies in the range of 10,001 to 35,000 population size (Table 3.1). The sample size was taken as 315, which is between low and high. 315 respondents

for household survey, KII and FGD were asked in different Institutions or Sectors and in local community. Lare Water and Energy Office Experts and Lare Town Water Supply and Sewerage Service, and different Offices or Desks which were using Water Services as they were selected purposively for KII and FGD structured interview.

Table 3.1: Sample Size Determination

Population size	Sample size		
	Low	Medium	High
51-90	5	13	20
91-150	8	20	32
151-280	13	32	50
281-500	20	50	80
501-1200	32	80	125
1201-3200	50	125	200
3201-10000	80	200	315
10001-35000	125	315	500
35001-150000	200	500	800

Source: (Nigusie et al., 2016)

3.3.2 Sampling Techniques

To select respondents from residents of Lare district which has 28 Kebeles, 35% of total Kebeles or 10 Kebeles were selected as a sample using Purposive Sampling Techniques. But in selecting the district villages and Water Supply Schemes from each sample Kebele, two villages per kebele and one Water Supply Scheme per village were selected by using probably stratified sampling method since the rural Kebelles were characterized by similar cultural settings and socio-economic conditions except the main town, Kuergeng.

3.4 Study Variables

Both independent and dependent variables were assessed in this study. Community factors, financial factors, institutional factors, technical factors, environmental factors, stakeholders' contribution and schemes functionality are independent variables but sustainability of rural water supply is taken as dependent variable which changes with respect to the conditions.

3.5 Data Collection Process

Data were collected through questionnaire, observation, and structured interview like key informant interviews (KII) and focus group discussions (FGD). The questionnaires were clear, easy to read and understand, and the sequence of the questions was easy to follow and the researcher was using non participant observation.

3.5.1 Primary Data Collection Process

Primary data were collected through observation, interview and questionnaire with local administration, households and other water users. There were 49 questions in the questionnaire, 18 questions in structured interview (10 questions for KII and 8 questions for FGD) and 9 questions for observation check list (Annex 1,2,3 and 4).

3.6 Materials and Software that were used

- Digital Camera
- Microsoft Excel
- SPSS
- Arc GIS for delineation and mapping the Study Area

3.7 Data Processing and Analysis

Data were edited and coded before analysis then for analysis of data that had been collected, a combination of quantitative and qualitative analysis method was employed. Thus, binary response and Likert scale were used by the researcher for data coding/testing.

Both descriptive and inferential data analysis had been used. The quantitative data which had been generated from households' survey were analyzed using descriptive data analysis tools such as standard deviation, mean and frequency/percentage.

Descriptive statistics is used to summarize and graph the data for the group that you choose while inferential data analysis tool is used to infer whether the association is significant in the population or not. Bivariate Pearson correlation is used to analyze continuous variables and it is used to measure the correlations among pairs of variables and correlations within and between sets of variables.

They were operated with Statistical Package for Social Studies (SPSS) and Microsoft Excel. SPSS was important to analyze survey data which were collected, and the result was in the form of tables, graphs or charts. Qualitative data that had been collected through key informant interviews, focus group discussions and field observation were used to triangulate the findings of quantitative survey.

3.8 Data Quality Assurance

- All the questions were put in clear and simple way
- Fieldwork manual was prepared to check every day work progress.
- The researcher was supervising data collectors throughout the time of data collection
- There was an orientation for data collectors that had been given by the researcher to know how to approach households and other respondents to keep the objectives of the study.

4. RESULT AND DISCUSSION

4.1 Source of Water Supply for Residents of Lare District

The source of rural water supply in Lare District is traditional hand dug wells, ponds, swamps, boreholes and piped water from main town and rural villages. From (Figure 4.1), 25% of the respondents get their water from surface water sources such as ponds and swamps and 75% from ground water sources like; boreholes, traditional hand dug wells and piped systems. This indicated that those who get their water from surface source were using untreated water source which may have negative health effect on their bodies.

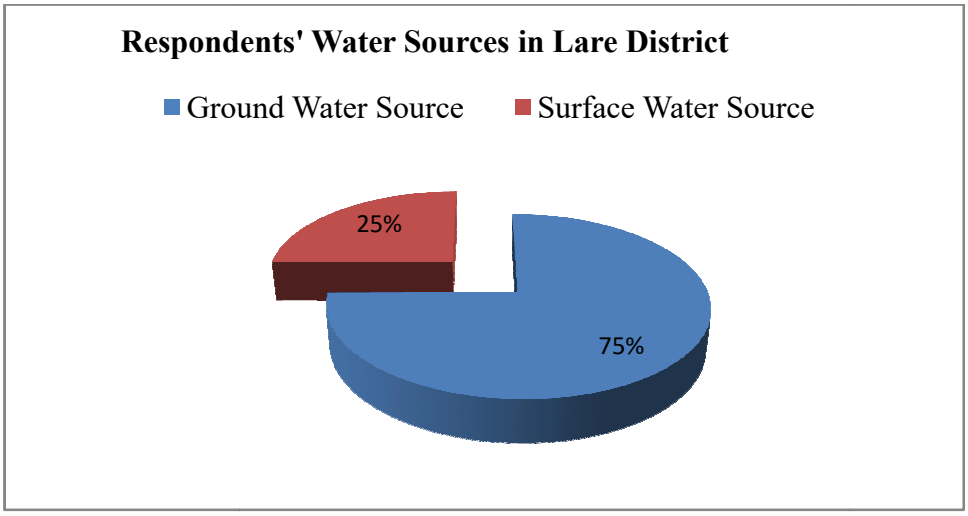


Figure 4.1: Water Sources in the Study Area

4.2 Factors Affecting Rural Water Supply Sustainability

4.2.1 Lack of Community Participation in the Water Point Management

According to the assessment that was done in a focus group discussion and key informant interview, they said that lack of community participation in water point management was not a problem. Every hand pump and water point scheme has 5 Committees to report every water problem. For FGD and KII some photographs were taken during discussions as it is shown in (Figure 4.3).

In the (Figure 4.2), only small percentage (31.1%) of respondents, responded that lack of community participation in water point management could be the cause for unsustainable rural water supply schemes. This means large number of respondents disagree that lack of community participation should not be the main problem. The result showed that lack of community participation in water point management of rural water supply schemes could not be the cause for rural water supply schemes for not being sustainable. This means more than half/50.8% respondents said it could not be lack of water point management that could cause the problem.

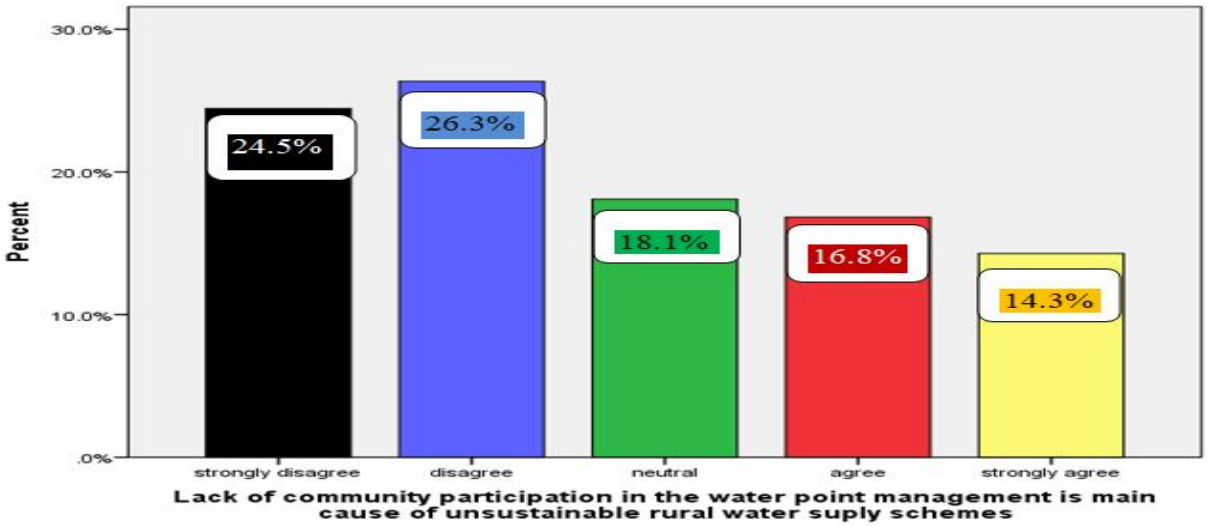


Figure 4.2: Graph for Lack of Community Participation in Water Point Management in Lare District

Figure 4.3: Photographs taken at the time when investigating Community Participation in the Study Area; a, for FGD and b, for KII

4.2.2 Lack of Finance for Operation and Maintenance Service Activities

Lack of finance is included in economic factors such as shortage of budget, high level of poverty, low level of household income, high cost of technologies and affordability to those who are paying for services. Financial support is the important factor for the functioning of any water supply scheme. From this assessment, financial support was

assessed and the lack of financial support for operation and maintenance was the one among major problems that cause un-sustainability of rural water supply schemes.

In the (Figure 4.4), many respondents agreed and strongly agreed that lack of finance for operation and maintenance was the main cause of unsustainable rural water supply schemes. The others were neutral, disagreed and strongly disagreed respectively.

Therefore, the result indicated that 61.6% accepted lack of finance for operation and maintenance activities was one of the factors that affect sustainability of rural water supply schemes.

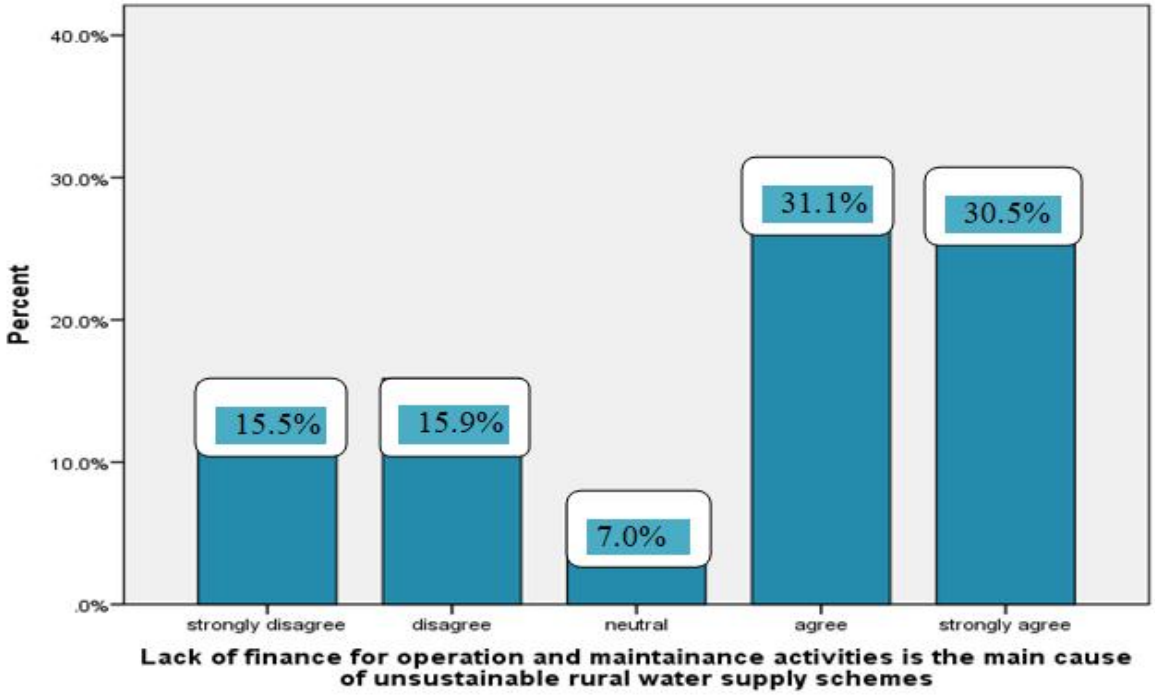


Figure 4.4: Graph for Lack of Finance for Operation and Maintenance in Lare District

4.2.3 Lack of Support and Supervision from District Water Desks

Districts are responsible for planning and managing their own programs, financial and procurement management, monitoring and evaluation, and for contracting and supervising Local Service Providers at District and community levels. But the factors hindering all these should be studied.

Under institutional factors include absence of guidelines and policies, absence of participatory planning and weak coordination of staffs in all rural water supply activities carried out in the District. Sectors policies lack clarity over the mechanism of how services can be equitably provided to the local community. Policies and guidelines are much needed in the community level as stressed in focus group discussion.

Therefore, support and supervision from office of Water, Mineral and Energy Development is crucial in sustaining water supply schemes. In the (Figure 4.5) from this assessment; Many people of strongly agreed and agreed that there is lack of support and supervision from water desk and others were neutral,disagreed and strongly disagreed respectively. Therefore, 61.6% revealed the existing of unsustainable rural water supply schemes due to lack of support and supervision from from Lare Rural Water Desks.

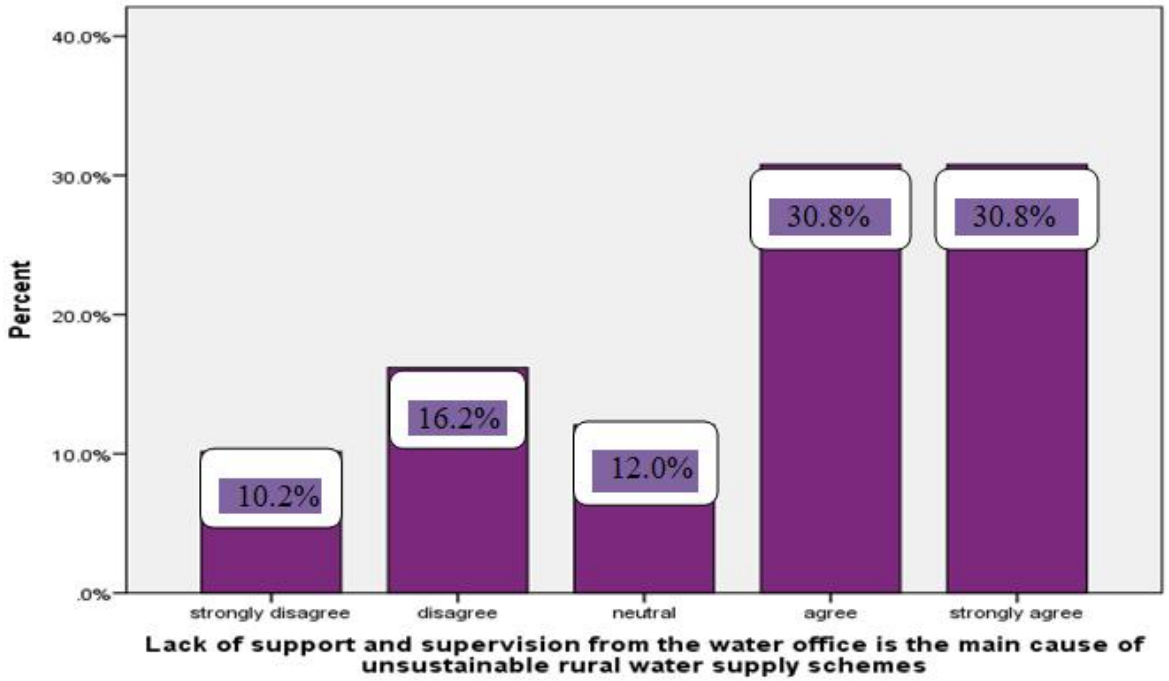


Figure 4.5: Graph for Lack of Support and Supervision from Water Desks in Lare District

4.2.4 Technical Assessment on Technicians and Spare Parts

I, Technical assessment on Technicians

Technical factors are so vital to the sustainability of rural water supply schemes. From (Figure 4.6), 126(40%) and 81(25.7%) were agreed and strongly agreed respectively that lack of qualified technicians is the main cause for unsustainable rural water supply schemes. The others of respondents were neutral, disagreed and strongly disagreed. As the result revealed, there is technical problem in the study area. Therefore, lack of qualified local technicians is one of the main factors that affect sustainability of rural water supply schemes. This showed that 65.7% responded that lack of local technicians caused unsustainable rural water supply in the study area.

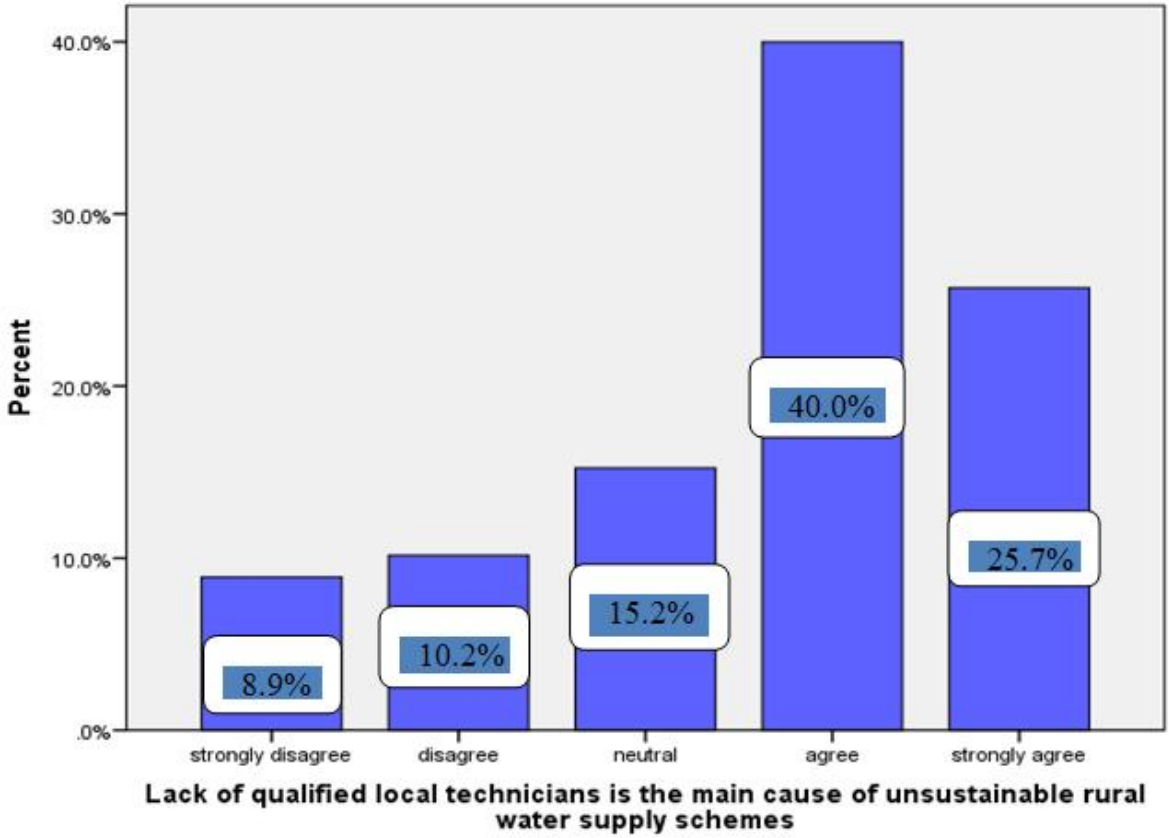


Figure 4.6: Graph for Lack of Qualified Local Technicians in the Study Area

II, Technical Assessment on Spare Parts

As the researcher observation of water distribution system in Kuergeng Town, Lare district, out of ten water chambers/manholes in the town, only one was working which was

near to water distribution tank. When there is any water leakage of pipe/un-functionality of one water point, the gate valve near to the reservoir is shut and this will result in total shutting down of town water. See (Figure 4.8) for the photographs taken during investigations. Lack of spare parts was the great problem in the district. Many water supply schemes/hand pumps which were not working were not rehabilitated due to lack of spare parts. According to the result from (Figure 4.7), 99(31%) of the respondents agreed that there are no spare parts provided for the maintenance of schemes and 79(25%) strongly agreed for the lack of provisions of spare parts. The rest strongly disagreed, disagreed and neutral. This means 56% responded that there was technical problem in the Town due to lack of spare parts.

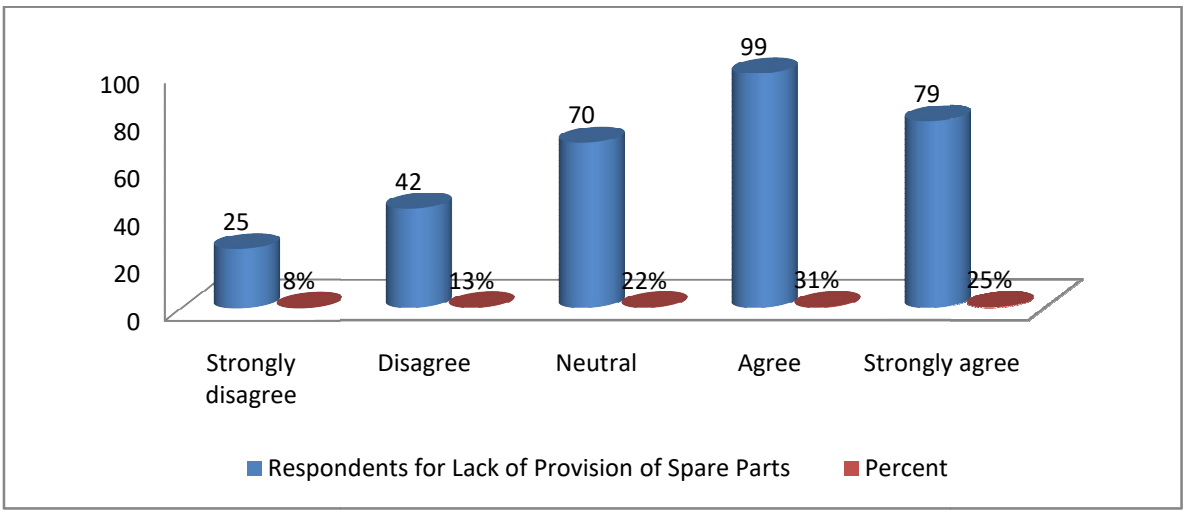


Figure 4.7: Graph for Result of Lack of Spare Parts in Lare District

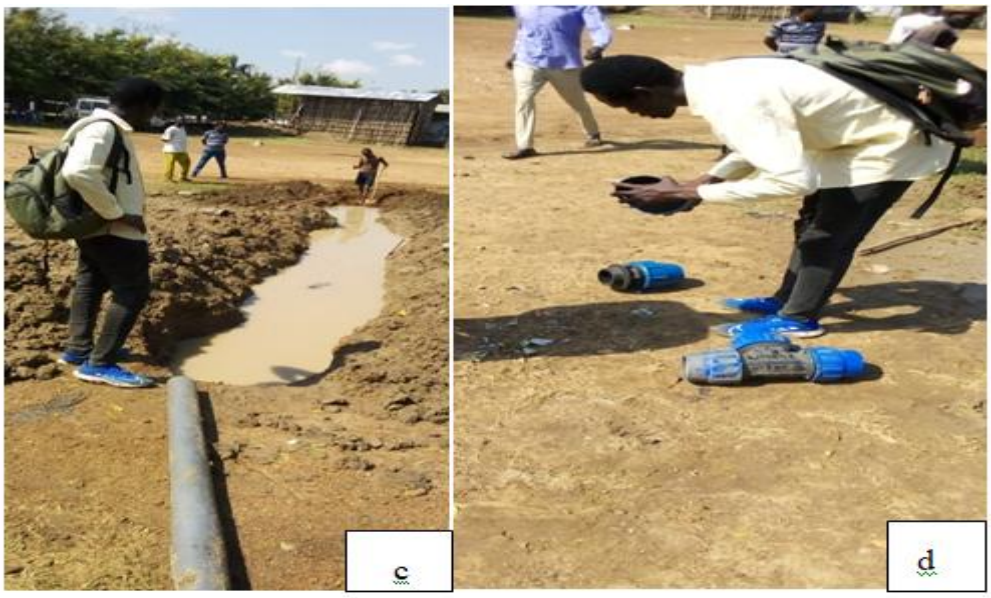


Figure 4.8: Photographs taken during Technical Investigation of Spare Parts in Kuergeng Town; c, Observing the broken Pipeline and d, Observing Spare Parts

4.2.5 Environmental Factors

Factors that affect sustainability of rural water supply schemes are essential to know and environmental factor is one of the factors that were assessed in Lare district. As the observation of the researcher, many water supply schemes were found in swampy areas. In summer and autumn, water supply schemes are flooded and are submerged in water. As the result, the soil is expanded (Figure 4.10). However, during the dry season, that is winter and spring, the soil becomes shrinking when the water is receded. Due to these reasons, the water supply platforms, drainages and cattle troughs/catchments are broken. Within this result from (Figure 4.9), 108(34.3%) strongly agreed that there was a problem on environment, 90(28.6%) agreed also on the problem, but 61(19.3%), 40(12.7%) and 16(5.1%) respondents were neutral, disagreed and strongly disagreed respectively. This result revealed that 62.9% responded that there was a problem on environment which must be the cause for unsustainable rural water supply.

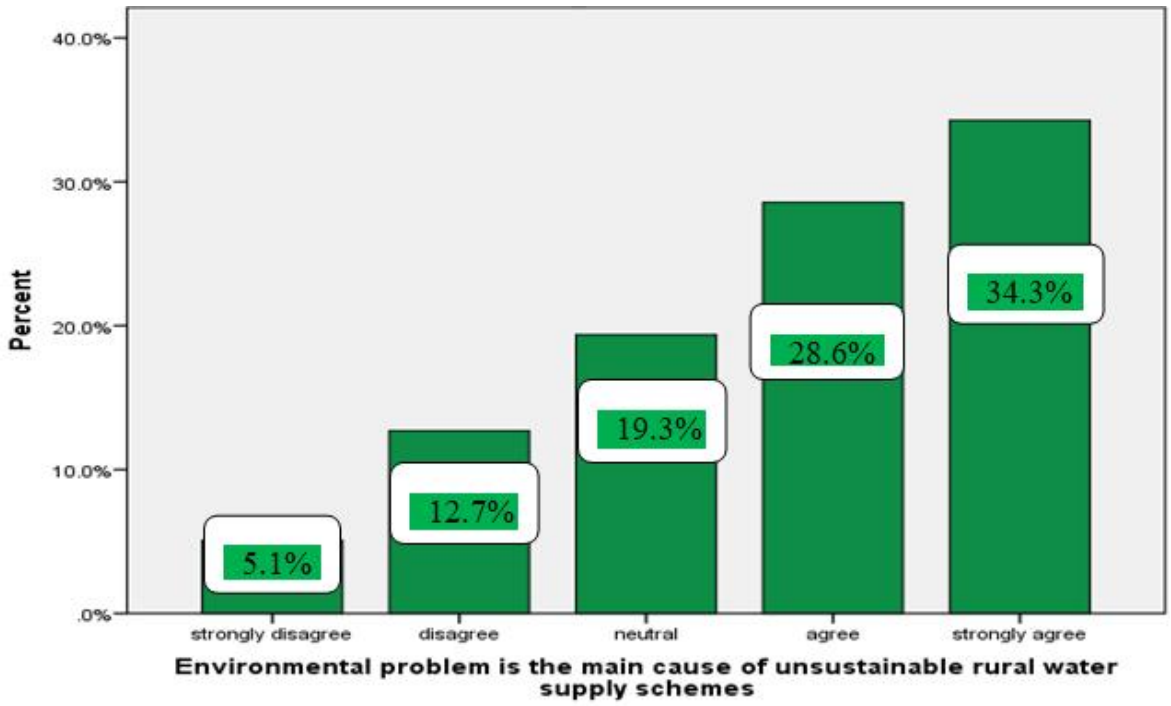


Figure 4.9: Graph for Environmental Problem in the Study Area

Figure 4.10: Photographs that showed the Environmental Problem from Lare District; e, in Kuergeng Town and f, in Rural Village

Table 4.1: Key Factors Affecting Rural Water Supply Schemes Sustainability by using AHP for Weighting the Dominant Factor

Pair-Wise Comparison Matrix

	Community Factors	Financial Factors	Institutional Factors	Technical Factors	Environmental Factors
Community Factors	1	0.33	0.2	0.11	0.14
Financial Factors	3	1	0.33	0.14	0.33
Institutional Factors	5	3	1	0.2	0.2
Technical Factors	9	7	5	1	3
Environmental Factors	7	3	5	0.33	1
Sum	25	14.33	11.53	1.78	4.67

Normalized Pair-Wise Comparison Matrix

	Community Factors	Financial Factors	Institutional Factors	Technical Factors	Environmental Factors	**Criteria Weights**	**Rank**
Community Factors	0.04	0.0230	0.0173	0.0618	0.02998	**0.0344**	**5**
Financial Factors	0.12	0.0698	0.0286	0.0787	0.0707	**0.0736**	**4**
Institutional Factors	0.2	0.2094	0.0867	0.1124	0.0428	**0.1303**	**3**
Technical Factors	0.75	0.4885	0.4337	0.5618	0.6424	**0.5753**	**1**
Environmental Factors	0.28	0.2094	0.4337	0.1854	0.2141	**0.2645**	**2**

Therefore, according to the estimated weights, the most dominant factor is Technical factor followed by Environmental factor. For consistency checking in this Analytic Hierarchy Process (AHP), it is found in (Annex 13).

4.3 Stakeholders' Contribution on Rural Water Supply Development

Stakeholders such as local community, government institutions/sectors and NGOs are the main contributors on rural water supply development. Stakeholders' contribution is important factor for sustainability of rural water supply schemes. In (Figure 4.11), the result indicated that 132(42%) participated in management aspect, 95(30%) not participated in all phases, 68(22%) involved in construction phase, 11(3%) participated in all phases and only 9(3%) participated in planning.

This indicated that these stakeholders do not participate equally during project development. Only small percentage of stakeholders participated at planning stage and in all phases. Therefore, findings from stakeholders showed the absence of clear mechanism to participate equally in all phases of projects. According to focus group discussion held in the study area, many people said community participation in the planning process was very much limited and stakeholders were not included in all phases. This means that lack of joint planning and coordination of key stakeholders negatively affects sustainability of rural water supply.

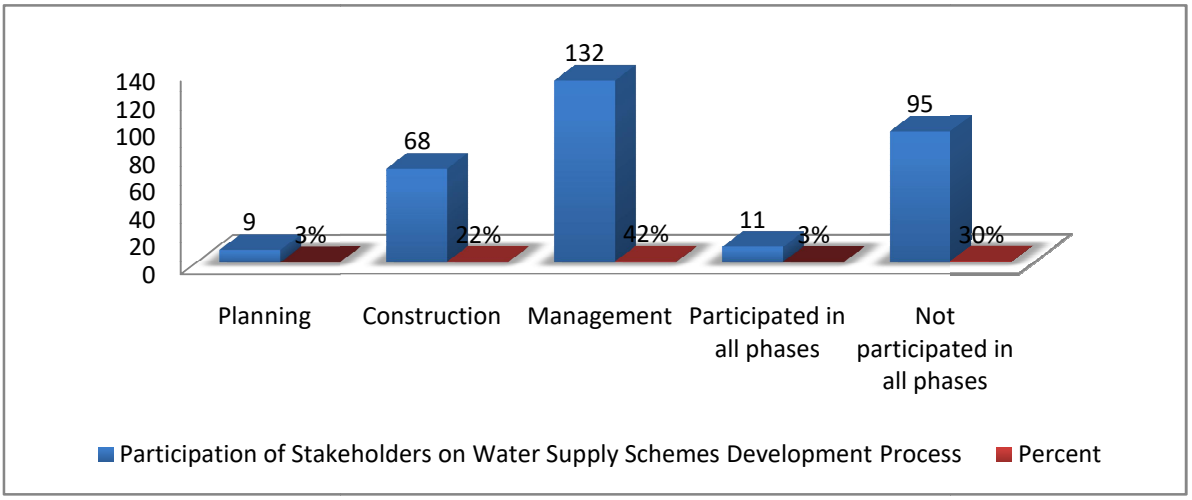


Figure 4.11: Graph Indicating Stakeholders' Contribution in Lare District

4.3.1 The Idea to Improve Water Supply Schemes and Choosing Technology

Improvement of of water supply schemes and how to choose their technology has so much contribution on how participation of local community, government or NGOs is assessed. Therefore, from the initiating water supply improvement in (Table 4.2), 122(38.7%) answered that rural water supply improvement idea came from the community, 167(53.0%) from government, 26(8.3%) from NGOs.

In choosing the technology of the projects, 64(20.3%) answered that the idea came from the community, 234(74.3%) from government, 17(5.4%) from NGOs and 19(6.7%).This indicated that the idea to improve rural water supply schemes and choosing technology of the projects mostly came from government. Local community come next to government and NGOs as the last one in having idea to improve water supply schemes and choosing technology.

Table 4.2: Idea to Improve Water Supply Schemes and Choosing Technology of the Project in Study Area

Who came up with an idea to improve water supply scheme?		
Respondents	Frequency	Percent
Local community	122	38.7%
Government	167	53.0%
NGOs	26	8.3%
Total	315	100%
Whose idea was it to choose the technology of the project?		
Local community	64	20.3%
Government	234	74.3%
NGOs	17	5.4%
Total	315	100%

4.3.2 Contribution on Operation and Maintenance Activities of Water Supply Schemes

Operation and maintenance for rural water supply needed to be assessed thoroughly since much failures are available after construction of rural water supply schemes. Here participation of stakeholders; District Water Desks, local community and others like NGOs were assessed, and the result revealed from total of 315 respondents, 207(65.7%) responded that the operation and maintenance had been done by Lare Water Desk, 95(30.2%) responded that operation and maintenance had been done by NGOs and only 13(4.1%) had been done by the local community (Figure 4.12).

According to focus group discussion held at this district, some NGOs such as UNICEF and Samaritan's purse used to contribute by paying money for operation and maintenance of non-functional schemes. Therefore, government and NGOs make more contribution on rural water supply schemes sustainability by participation in operation and maintenance.

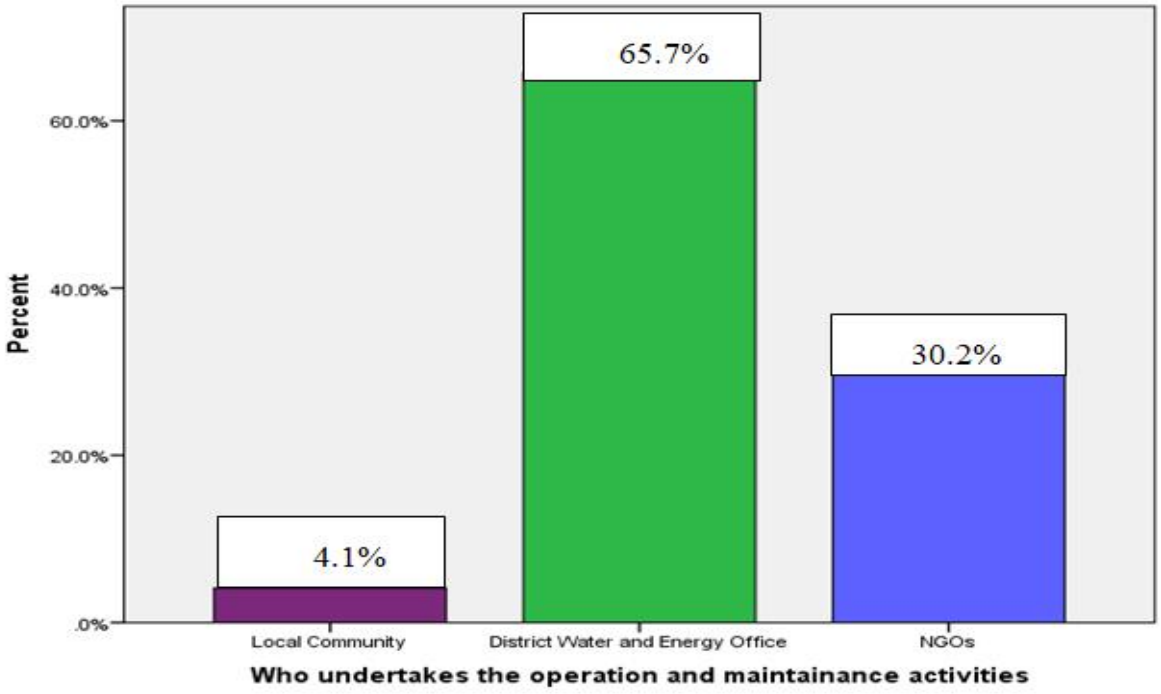


Figure 4.12: Contribution on Operation and Maintenance in Lare District

4.4 Rural Water Supply Functionality Factors

4.4.1 Distance from the Water Sources at Lare District

As the researcher observation, most of the rural water supply schemes were found at a distance above 1.5 km from residents due inaccessibility of rural water supply schemes. See (Figure 4.14) for the pictures of households' survey. From the result in the (Figure 4.13), only 4% of respondents were living below 0.5 km, 19% were from 0.5 to 1 km, 38% were from 1 to 1.5 km and 39% were very faraway beyond 1.5 km. This means only 23% meets the 2016-2020 G.C Growth and Transformation Plan (GTP-2) and Universal Access Program (UAP) which were introduced in Ethiopia. According to GTP-2 set by World Bank, rural water supply access should be with the minimum service level of 25 l/c/d within a distance of 1 km from the water delivery point for 85% of the rural population of which 20% are provided with RPS, and 30 minutes round trip and queuing time. 77 % did not meet the target set in GTP-2. Therefore, more effort is needed by all Gambella people in order to tackle this problem to be in a radius of 1km with round trip within 30 minutes.

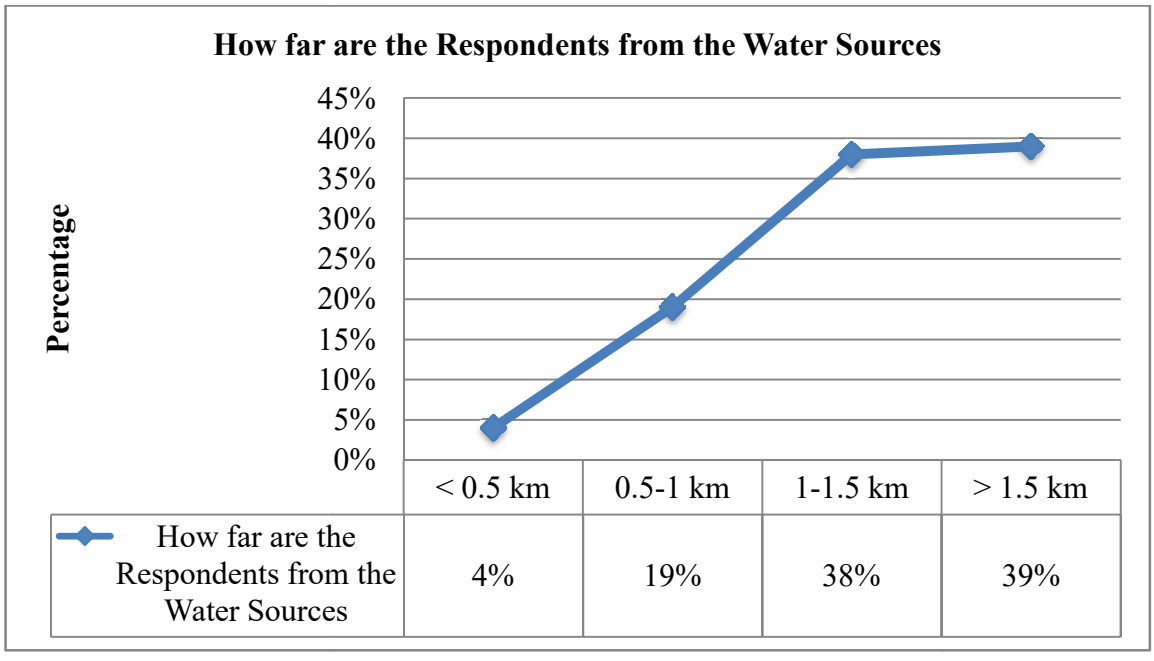


Figure 4.13: Line Graph showing the Distance from Water Sources in Lare District

Figure 4.14: Photographs taken during Households' Survey moving from house to house; g, at Ngor village and h, at Teluth village

4.4.2 Time Spent on Queue for Fetching Water

The time spent on a queue for fetching water was asked from the respondents and the following was the result obtained. 7% of Respondents spent less than 15 minutes, 15% spent 15 to 30 minutes, 17% stayed for 31 to 45 minutes, 26% stayed for 46 to 60 minutes and 35% of Respondents were above 60 minutes (Figure 4.15). The total time to travel and wait on a queue must be in line with strategic plan for rural water supply. As the result revealed, 22% met the Universal Access Plan Program which accepts 30 minutes for round trip and waiting on queue for fetching water. In the (Figure 4.16) were the photographs taken during waiting time investigation on queue. This means 78% of population did not meet the target plan set in GTP-2, World Bank. 78% did not meet water fetching travel time which is from 30-60 minutes according to Water Supply Service Level Ladder which was set by World Bank (Moriarty et al., 2011).

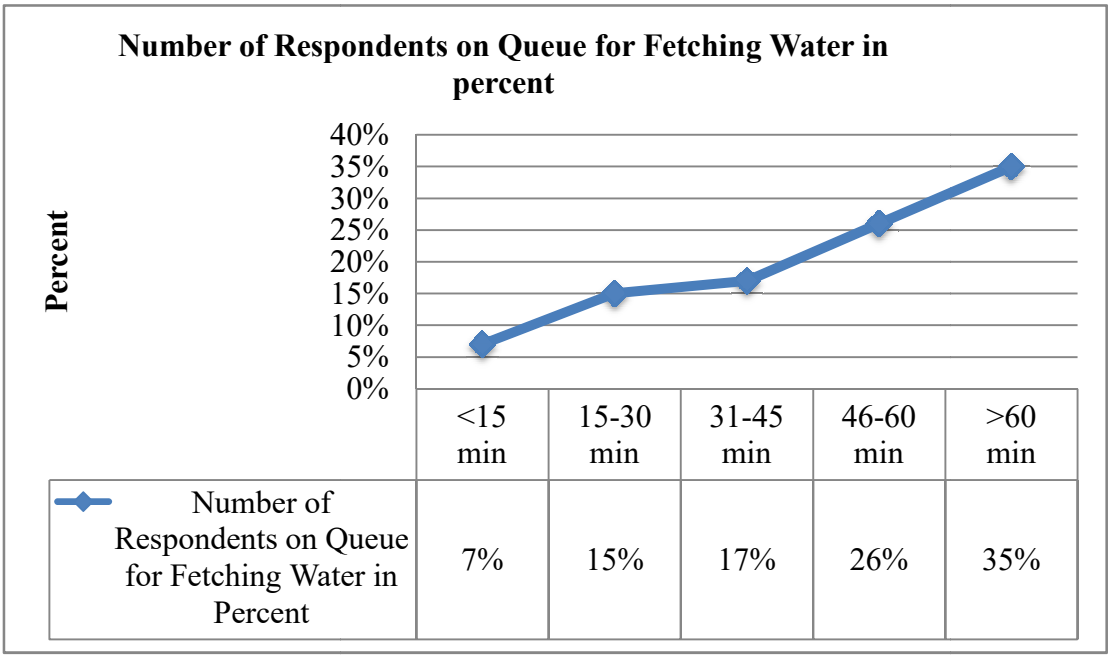


Figure 4.15: Graph showing time taken on Queue for Fetching Water in Lare District

Figure 4.16: Photographs taken during investigations for time taken on Queue for Fetching Water in Lare Rural Water Supply Schemes; i, Koat-manchuong, j, Koat-Mchar and k, Gospel

4.4.3 Water Quality Problem

During assessment of physical parameter of water quality in Lare district, Water quality of the rural water supply schemes has so many problems such as odor, color and taste which are the physical parameters. According to observation and focus group discussion, many water supply schemes were polluted by surface run off as it was shown in (Figure 4.18). During rainy season water supply schemes are submerged in flood water. The result showed that from 315 of the respondents 216(69%) people responded that there was water quality problem and 99(31%) people did not have water quality problem, (Figure 4.17).

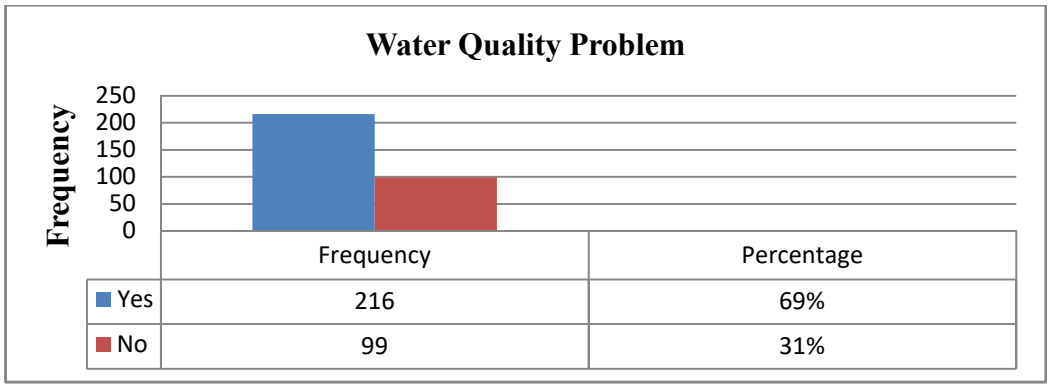


Figure 4.17: Graph for Water Quality Problem in Lare District

Figure 4.18: Physical Parameters of Water Quality Investigation Photographs in the Study Area

4.4.4 Functionality of Existing Water Supply throughout the Year

Lare district has a total number of 166 water supply schemes of which were scarcely distributed in the villages. To determine the number of functional schemes in the study area, there should be realistic study in the district. Water supply functionality is the one of the factor for determination of factors affecting sustainability of rural water supply schemes. If water supply schemes function well for long period of time there should be no problem at all.

However, many rural water supply schemes were not working due to different factors such as poor construction, poor maintenance after it fails to function, uncaring for boreholes usage, children playing with hand pumps, banging of the handles of water points, not monitoring the pumps properly by the community and district water desk, and not fencing the water points. See (Figure 4.19).

Figure 4.19: Photographs for Non Functional and Partial Functional Rural Water Supply Schemes in the Study Area

4.4.5 Water Supply Service Coverage in Lare District

Water service coverage is the number of people to each household in the district, ideally with water available 24 hours a day and 7 days a week to meet existing demand. The best

measure of a good water supply service in the district is the number of people with 24 hours access to water supply schemes near them. That is why service coverage is the most important performance parameter of any water supply scheme/ utility (MoWE, 2012; Mcintosh, 2014).

In Lare district, the existing water supply schemes do not fully satisfy service coverage demand of the population. The problem arises due to the following reasons; the sources which are far from homes, rapid population growth and scarcity of the water.

In this district, water supply service coverage was 74% from the total population of 51,367 then 26 % of the total population had no access to water supply schemes. (Figure 4.20) shows Lare district water service coverage. This 74% is less than water coverage set in GTP-1 which was 98% for rural areas and is also less than the water service coverage found in Debre Markos which was 77% (Daniel, 2016).

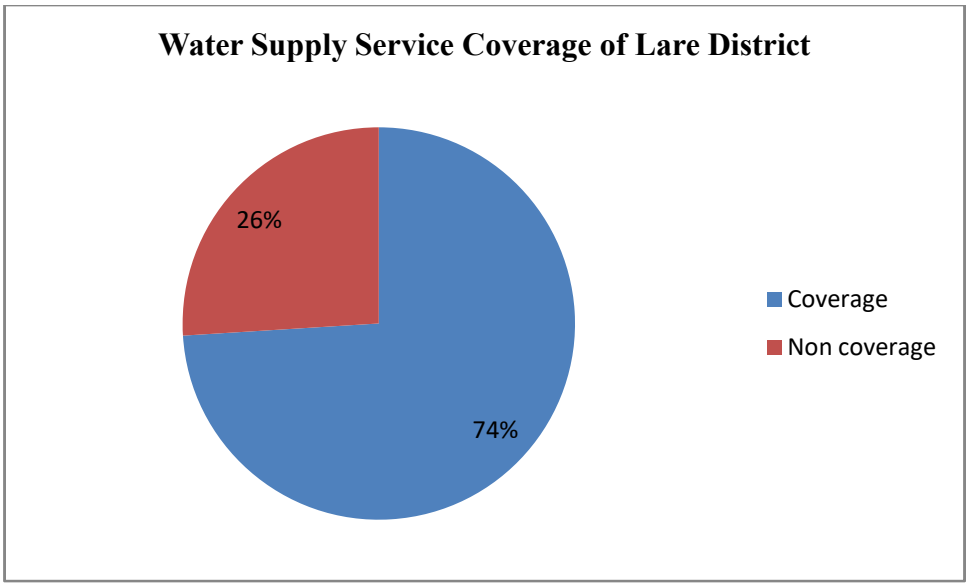


Figure 4.20: Water Supply Service Coverage of Lare District

4.4.6 Water Consumption Quantity

Water consumption for each households needed to be determine as it is good enough to understand whether drinking water is enough or not. Here is the result shown from (Table 4.3) for water consumption; 24.1% responded that drinking water supply was enough and

75.9% responded that drinking water supply was not enough due to scarcity of water and distance that was very far from residents. Therefore, as the result indicated, more people were suffering due to lack of drinking water supply. In (Figure 4.21) are the pictures captured during water consumption assessment.

Table 4.3: Quantity of Water Consumption in the Study Area

Water Consumption quantity		
Respondents	**Frequency**	**Percent**
It is enough	76	24.1%
It is not enough because the source is far from home	126	40.0%
It is not enough because of water scarcity	113	35.9%
Total	315	100%

Figure 4.21: Photographs taken during Water Consumption Investigations in Lare District

4.4.7 Family Size and the number of Jerry cans Fetched per day

Family sizes have much more contribution on water consumptions in the households. Therefore, households who have a big number of family sizes have great effect on water uses, allocations and collections. In the result, with N=315, the minimum number of family

size was 2 and the maximum was 20 with the mean of 9.87 and standard deviation of 3.63 family sizes. The Pearson's correlation between the family sizes and the number of Jerry cans fetched is negatively correlated with r= -0.124 and statistically significant with p=0.028. That means as the family size increases the number of Jerry cans fetched decreases and the strength of their association is weak. (Table 4.4, Table 4.6 and Annex 7).

Table 4.4: Family Size of Respondents in the Study Area

Number of family size of the Respondents	Frequency	Percent
2	9	2.9%
3	9	2.9%
4	12	3.8%
5	15	4.8%
6	21	6.7%
7	15	4.8%
8	14	4.4%
9	39	12.4%
10	27	8.6%
11	37	11.7%
12	46	14.6%
13	33	10.5%
14	12	3.8%
15	13	4.1%
16	5	1.6%

17	3	1.0%
18	2	0.6%
19	2	0.6%
20	1	0.3%
Total	**315**	**100%**

4.4.8 Amount of Payment for Fetching Water

The corresponding number of Jerry cans fetched per day was; the minimum was 1 and maximum was 16 with the mean of 2.70 and standard deviation of 1.40. That means to know how many liters p/c/d you can divide the average number of Jerry cans by average number of the households multiply by 20 liters for each Jerry can.

This is below the standard in GTP-2 planned by the World Bank which is 25 l/c/d from 2020-2025 G.C and it is also below the standards in Water Supply Service Level Ladder (Moriarty et al., 2011) which set the Water Service Level as 20-40 l/c/d for basic sanitation. It indicated that water supply consumption is not sufficient in the households living in Lare district. (Table 4.5, Table 4.6 and Annex 7).

Table 4.5: Number of Jerry Cans Fetched per day in Lare District

Number of Jerry cans fetched per day	**Frequency**	**Percent**
1	38	12.1%
2	127	40.3%
3	72	22.9%
4	73	23.2%
5	1	0.3%

8	1	0.3%
10	2	0.6%
16	1	0.3%
Total	**315**	**100%**

In term of payments, many people were not paying water tariffs due to unawareness from the authority/concerned body which have responsibility to aware communities for the importance of paying water tariff. Due to this reason, around 80% of respondents were not paying water tariff and only 20% used to pay water bill as shown in (Figure 4.22).

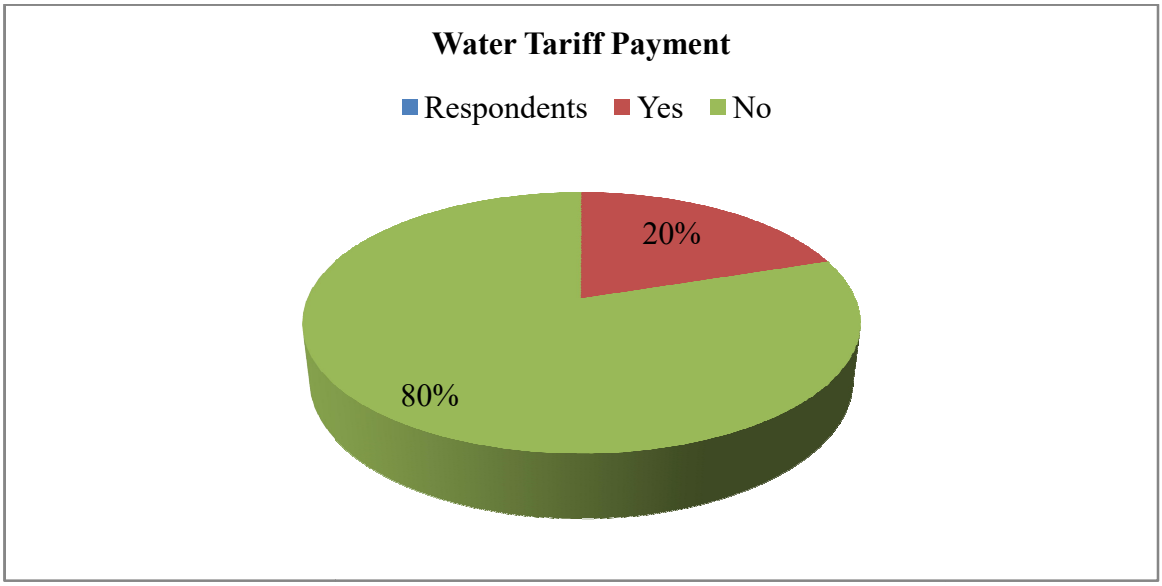


Figure 4.22: Water Tariff Payment in Lare District

The survey result revealed that the maximum amount of payment was16 Birr and the minimum was 0 with the mean of 0.60 and standard deviation of 1.62. The corresponding number of Jerry cans fetched per day was 16 maximum and the minimum was 1 with the mean of 2.70 and standard deviation of 1.40. Based on the result, the Pearson's correlation between the number of Jerry cans fetched per day and the amount of Birr paid for fetching water is as follow: Number of Jerry cans fetched and the amount of Birr paid have a

statistically linear relationship with r=0.630 and p<0.001. The direction of their relationship is positive and they do have strong correlation that is 0.5<|0.630|.

- 0.1<|r|<0.3 ... small / weak correlation
- 0.3<|r|<0.5 ... medium / moderate correlation
- 0.5<|r|.....large / strong correlation (Kent State University Libraries, 2017).

Table 4.6: Continuous Variables Analyzed by using Pearson's Correlation

		Family size of respondents	Number of Jerry cans fetch per day	How much do you pay for water
Family size of respondents	Pearson Correlation	1	-.124*	-.104
	Sig. (2-tailed)		.028	.066
	N	315	315	315
Number of Jerry cans fetch per day	Pearson Correlation	-.124*	1	.630**
	Sig. (2-tailed)	.028		.000
	N	315	315	315
How much do you pay for water	Pearson Correlation	-.104	.630**	1
	Sig. (2-tailed)	.066	.000	
	N	315	315	315

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research educed the factors affecting the sustainability of rural water supply schemes. Environmental factors affect the sustainability of rural water supply schemes greatly in this District. At every summer season, many rural water supply schemes are flooded due high rainfall in the summer since the land is low land.

After the rainy season when the soil is dry, it left great damages on platforms, drainages and cattle troughs. This is the main reason why many water supply schemes in rural area of Lare fail after construction.

The constructed rural water supply schemes do have water quality problems due the polluted environment during rainy season. The water has bad odor, taste and white or brownish color. 62.9% accepted that this is great problem in the study area.

Lack of finance for maintenance is the one of the factors that made rural water supply unsustainable. 61.6% indicated that there was financial problem. Those living in the villages were not aware of payment of money during fetching for maintenance when the system fails. Around 80% didn't pay water tariffs due to lack of awareness of importance of paying water tariffs.

There is lack of support and supervision from district water desks to local community due lack of spare parts in district water office. When there is any failure of the system the community may wait for so long for maintenance. 61.6% responded that the unsustainable rural water supply scheme was there due to lack of support and supervision from Rural Water Desks. Also there were no guidelines and policies for governing rural water supply schemes.

Lack of local technicians and spare parts were among the factors that affect rural water supply sustainability. 65.7% responded lack of local technicians was the main cause and 56% responded lack of spare parts was the great problem. This constituted 60.85% of technical factors. Most of Lare rural water supply schemes which were observed were not

fenced and water catchments were not constructed which may lead to poor managements of schemes.

The most dominant factor was technical factor with the weighted value of 0.5753(57.53%) followed by environmental factor with 0.2645(26.45%), and the other factors were institutional factor with 0.1303(13.03%), financial factor with 0.0736(7.36%) and community factor with 0.0344(3.44%).

All stakeholders do not participate equally during project executions or phases especially local communities were ignored during planning and did not participate equally with other stakeholders during projects development.

The large family size has the tremendous effect on water supply consumption. People living in villages have huge family sizes. The water that is collected from far distances would not satisfy the households' consumptions because many households collected water from a distance of more than 1.5 km radius and more than 30 minutes waiting on queue which does not meet the objectives of GTP-2 and UAP, World Bank. Therefore, the water consumption was less than 25 l/c/d which was planned in GTP-2 by the World Bank.

5.2 Recommendation

Finally, the result found in this finding agreed with many findings/results which were done by other researchers in other specific areas (Nigusie, et al., 2016). This district needs more help from either government or NGOs for more challenges they are facing to get sustainable water supply and potable drinking water. Water supply schemes should be constructed in elevated lands for flood protection or should be back filled above the flood level as they would not be overflowed by water during rainy season. The existing rural water supply schemes; hand pumps should be treated regularly after the flood or rain water receded.

Local community should be aware of importance of paying water tariff so they should have some amount of money for maintenance when their water supply schemes fail to function.

The District Water Desks should have a warehouse/store for spare parts, so when need arrives from local community, they should provide easily instead of waiting the regional government or NGOs for provision in unknown time.

Fencing/deploying of security guards for protection of water supply schemes/water points is needed, and catchment construction of schemes could be done to avoid stagnancy of water around the platforms of hand pumps.

The local community needs to be included during planning and should participate in all phases of project developments. Therefore, more researches are needed for further study to tackle the real situation of this District.

To alleviate all these rural water supply problems, more rural water supply schemes should be constructed in this specific area which faces a problem of not having sufficient and potable drinking water in order to meet GTP-2 and UAP objectives set by World Bank.

REFERENCES

Abrams, L., 2013. Understanding Sustainability of local water service: The African water page, Retrieved in August, 2013.

African Development Fund, ADF, 2005. Rural Water Supply and Sanitation program appraisal report: Infrastructure department, North, East and South, ONIN, ADF

Amjad, U.Q., Ojomo, E., Downs, K., Cronk, R. and Bartram, J., 2015. Rethinking Sustainability, Scaling up, and enabling environment: A framework for their implementation in drinking water supply. *Water*, *7*(4), pp.1497-1514.

Borowy, I., 2013. Defining Sustainable Development for our Common Future: A history of the World Commission on Environment and Development (Brundtland Commission). Routledge.

Brikké, F. and Bredero, M., 2003. Linking technology choice with operation and maintenance in the context of community water supply and sanitation, Reference Document for Planners and Project Staff, WHO and IRC International Water and Sanitation Center (IRC), Geneva.

Daniel, Y., 2016. Evaluating Hydraulic Performance of Urban Water Supply Distribution system: A Case Study of Debre Markos, East Gojjam Zone, Amhara Regional State, Ethiopia.

Fewtrell, L., Bos, R., Gore, F. and Bartram, J., 2007. Water, sanitation and hygiene: quantifying the impact at national and local levels in countries with incomplete water supply and sanitation coverage, WHO Geneva.

Frison, S.,Smith, J. and Blanchet, K., 2018. Does the humanitarian sector use evidence-informed standards? A review of the 2011 sphere indicators for wash, food security and nutrition, and health action. *PLoS currents*, *10*.

Giné, R. and Pérez-Foguet, A., 2008. Sustainability assessment of national rural water supply program in Tanzania. In *Natural Resources Forum* (Vol. 32, No. 4, pp. 327-342). Oxford, UK: Blackwell Publishing Ltd.

Habtamu, A., 2012. Factors affecting the suitability of rural water supply systems: Case Study of Mecha Woreda, Amhara Region, Ethiopia. Addis Ababa University, Professional studies.

Harvey, A. and Reel, A., 2007. Community managed water supply in Africa: Sustainable or Dispensable Community Development Journal vol. 42, No 3; July 2007.

Jones, S. Anya, A. Stacey, N. and Weir, L., 2012. A Life-cycle Approach to Improve the Sustainability of Rural Water Systems in Resource-limited Countries.

Kent State University Libraries., 2017. *SPSS tutorials: Independent samplestest.* RetrievedMay17,2017,fromhttp://libguides.library.kent.edu/SPSS/IndependentTTest.

Mcintosh, A.C., 2014. Urban Water Supply and Sanitation in Southeast Asia: A Guide To Good Practice, Available At: Http://Adb.Org/Sites/Default/Files/Pub/2014/UrbanWater-Supply-Sanitation-Southeast-Asia.Pdf.

Mebrahtu, M., 2012. Assessment of CMP Approach in developing rural water supply schemes: Benishangul-Gumuz, Ethiopia (M.Sc. Thesis, Addis Ababa University).

Mehta, L., 2000. Water for the twenty-first century: challenges and misconceptions.

Mema V. and Mothetha M., 2013. Technical reports for Vondo cluster, CSIR Pretoria, South Africa

Mengesha, A., Abera, K. &Mesganaw, F., 2002. Sustainability of Drinking Water Supply Projects in Rural of North Gondar Ethiopia: Ethiopian J. Health Dev, vol.2.

Ministry of Water Resources (MoWR), 2006. Universal Access Program, (UAP) for water supply and sanitation service from 2006 to 2012, Addis Ababa, Ethiopia.

Ministry of Water Resources (MoWR), 2007. Ethiopian Water Resource Management policy, The Federal Democratic Republic of Ethiopia: Minister of Water Resource.

Moriarty, P., Butterworth, J., 2003.The productive use of domestic water supplies. How water supplies can play a wider role in livelihood improvement and poverty reduction. (IRC Thematic Overview Paper Series) [online] Delft: IRC International Water and Sanitation Centre. Available at: [Accessed 27 October 2011].

MOWE, 2012. Training Manual and Guideline for Performance Indicators and Bench marking for Utilities, Water, Addis Ababa, Ethiopia: Federal Democratic Republic of Ethiopia Ministry of Water and Energy.

Ndaw, M.F., 2016. Private Sector Provision of Water Supply and Sanitation in Rural Areas and Small Towns: The Role of the Public Sector-Guidance Note. The World Bank.

Nigusie, K., 2016. Assessing Water Supply Coverage and Water loss in distribution system of Weliso Town, South West Shoa Zone, Oromia Region, Ethiopia.

Selamawit, A., 2007. Evaluation of Technical Sustainability of Rural Water Supply Projects in the Amhara Regional State Case Study in South Wollo, 2007, Addis Ababa.

SNV, 2013. Functionality: the challenges to rural water supply service, practice brief.

Tigist, M., 2014. Factors affecting the suitability of rural water supply systems, in menz mama Wereda Amara Region, Ethiopia.

UNICEF/WHO, 2012. Progress on drinking water and sanitation: 2012 update. WHO/UNICEF:Joint Monitoring Program for Water Supply and Sanitation, UNICEF, New York.

Wallace, S.G. and ET A., 2008. Safe Water as the Key to Global Health: United Nations University International Network on Water, Environment and Health (UNU- INWEH).

WHO, 2008. Guidelines for Drinking water quality incorporating the first and second Agenda; World Health Organization, Geneva Switzerland, Vol.1

Wonduante, 2013. Assessing the challenges of sustainable water supply in Gondar Town, Ethiopia.

World Bank Regional Reports, 2001. World Bank Regional Reports–Africa Region,RetrievedOctober8,2013.fromhttp://web.mit.edu/urbanupgrading/upgrading/casexamples/overviewafrica/regional overview.html

Zemenu, A., 2012. Assessment of challenges of sustainable water resource supply: QuaritWoreda, Amhara Region Ethiopia.

ANNEXES

Annex 1: Questionnaire for Households Survey or Community Survey

District: Lare, Kebelle: _____, Village: _____, Date: _____

Questionnaire No: _____

1. Sex of respondent

   A, Male B, Female
2. Age range of respondent

   A, 15-30 B, 31-45 C, 46-60 D, Above 60 years old
3. Religion of respondent A, Muslim B, Christian C, Pagan D, If there is any other specify _____
4. Current marital status

   A, Single B, Married C, Divorced D, Widowed
5. Household family size A, 5 and below B, 6-8 C, 9-11 D, Above 11
6. What is the source of income? A, Farming B, Government worker/NGOs C, Trade/Commercial D, Daily labor
7. Respondent income range per Month? A, < 3,000 birr B. 3,001-6,000 birr C, 6,001-9000 birr D, > 9000
8. Educational level of respondent

   A, Not read and write B, Primary school C, Secondary school D, Preparatory program E, Higher education
9. How many years have you lived in this area? A, < 1 year B, 1-5 year C, 5- 10 year D, above 10 year
10. Who came up with the idea of developing improved water supply? A, The community B, Governmental offices C, NGOs D, if other specify _____
11. Whose idea was it to choose the type/ technology of the project? A, The community B, Governmental offices C, NGOs D, if other specify _____

12. What was the source of the project funding? A, The community B, Government C, NGOs D, if other specify _____
13. How far is the water source from the house? A, < 0.5 km B, Between 0.5 and 1 Km C, Between 1 and 1.5 km D, Above 1.5 km
14. Time spend on queue for fetching water
    A, < 15 Minutes B, 15-30 Minutes C, 30-45 Minutes D, 45-60 Minutes E, Above 60 Minutes
15. Are the existing water supply schemes functional throughout the year? A, Functional B, Nonfunctional C, Partially functional
16. Who under takes the operation and maintenance activities when the schemes get failures? A, local technicians B, District Water and Energy Office C, Both
17. Types of water source? A, Ground B, Surface
18. Lack of good water sources is the main cause of unsustainable rural water supply schemes. A, Strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree
19. Lack of provision of spare parts is the main cause of unsustainable rural water supply schemes. A, Strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree
20. Lack of community participation in the water point management is the main cause of unsustainable rural water supply schemes. A, Strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree
21. Lack of qualified local technicians is the main cause of unsustainable rural water supply schemes. A, Strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree
22. Poor construction of scheme is the main cause of unsustainable rural water supply schemes. A, Strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree
23. Lack of support and supervision from the water office is the main cause of unsustainable rural water supply schemes. A, Strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree

24. Lack of finance for O& M service activities is the main cause of unsustainable rural water supply schemes. A, Strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree
25. Environmental problem is the main cause of unsustainable rural water supply schemes.
    A, strongly disagree B, Disagree C, Neutral D, Agree E, Strongly agree
26. At what season did the scheme constructed? A, wet season B, Dry season C, Other _____
27. Condition and existence of drainage facilities. A. Good B. Filled with mud C. there is no drainage facility D. Other _____
28. Is catchments construction done? Yes or No
29. Surrounding of the water supply source. A, Not clean at all B, Somewhat clean C, Very clean
30. Did the District Water and Energy Office provide support to water supply system in your community? A, Yes B, No
31. How do you see the adequacy of water sources? A, Adequate B, Inadequate
32. Did you face water quality problems while using existing water supply schemes? A, Yes B, No
33. At what stage of the development process did you participate? A, Planning B, Construction C, After construction in the management aspect D, Participate In all phases E, not participate at all stage
34. What was your contribution in development of the water supply schemes? A, Labor B, Money contribution C, local materials (stone, sand, wood) D, information provision, in site selection E, all of the above F, Other _____
35. Did you get any kind of training related with water resources management including operation, maintenances, diversification and sanitation? A, Yes B, No
36. Who is responsible for management of any water supply point scheme? A, Communities B, District water offices C, water committees D, only local NGOs

E, collaborations of all F, If other, please specify _____

37. Do you have good awareness on water resources management? A, Yes B, No
38. How many times Water point open per day? A, Once B, Twice C. all the day
39. What are the common practices of protection made to sustain the rural water supply? A, Paid guard and fencing B, Fencing C, Continuous protection and control by the User D, No protection
40. How many jerry cans do you fetch per day? _____
41. How do you feel about your water consumption? A, It is enough B, It is not enough because of water scarcity C, It is not enough because the source is far from home.
42. Do you pay any fee for using the water? A, Yes B, No
43. In the above question if your answer is yes, answer the following questions. How do you pay it? A, every time when water is fetched B, Monthly C, yearly D, If other specify_____
44. If you answer for question number "40" is no why? Because, A, water is considered as a gift of nature and should be provided for free B, no coordination in water tariff collection C, our water supply scheme is nonfunctional so our source is traditional point D, lack of awareness about the purposes of water fee
45. How much do you pay for water? _____
46. How do you perceive the existing water fees? A, expensive B, Fair C, Cheap
47. Is there any additional payment for operation and maintenances? A, Yes B, No
48. What type of penalty you have suffered if you fail to pay the fee? A, prevention from water fetching B, To pay twice of the normal tariff by coercion C, By using negotiate return to pay D, no measurement at all
49. What are your recommendations to sustain rural water supply systems?

Annex 2: Key Informant Interview

District: Lare

Lare Water and Energy Office, and Kuergeng Town Water Supply Agency

1. How many water supply schemes do you have in the District/Woreda?
2. What challenge do you face in any water scheme?
3. Do you have enough man power technically?

I, How many technicians do you have?

II, List all Water Staffs respective with their departments and positions

4. Do you give support for the community members after construction of the project?
5. What is your planned service value for rural water supply in term of?

Quantity

Quality

Accessibility

Reliability and how do you monitor it?

6. What are the institutional supports given for rural communities from your organization?
7. What are the major factors affecting planned rural water supply services value and scheme sustainability identified by your organization?
8. What are strategies your organization using to alleviate such problems and ensure rural water supply scheme sustainability?
9. How is the operation and maintenance of the water points addressed in your organization?
10. What kind of suggestions do you have to improve the operation and maintenance of the water points (schemes)?

Annex 3: Focus Group Discussion

District: Lare

Kebelle: _____, Village: _____, Number of people attending the group discussion: ____, Male: ____, Female_____, Date of discussion: _____

1. How many households are using the schemes? _____

2. What are the External (Institutional) supports you get after water supply schemes construction?
3. What kind of support provided by the bureau or Water office to community members (selected member for schemes protection)?
4. Who designs the water tariff rate?
5. What do you think about operation and maintenance of scheme?
6. From your experience, what major problems are encountered in relation to water supply schemes?
7. What solutions do you recommend in order to alleviate the problems and to sustain the functionality of the schemes?
8. What kind of solutions would you suggest in order to lengthen the operational life time of the water point?

Annex 4: Observation Check List or physical condition

Kebelle _____Village _____Name of Water Supply Scheme: _____, Types of Water Supply Scheme: _____,

Year of construction: _____

Technical and Social Acceptance

1. Availability of local skill for maintenance
2. Technical adequacy for desired level of service
3. Proximity from area of residence of users/ Distance from the nearest household _____
4. Proximity from the nearest agricultural lands _____
5. Is the area flood prone?
6. Is source protected from flooding and erosion?
7. Schemes constructed site socially acceptance
8. Match between population size and the available water supply facilities
9. Sanitary situations of the area

Annex 5: Fieldwork Manual to check every Work Progress during data collection

December, 2020					
Days of the Week	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Week 1					
Week 2					
Week 3					
Week 4					

Annex 6: Kebeles, Villages and type of Water Supply Schemes found in visited Study Area

Sr.No	**Kebele/Payam**	**Villages**	**Types of water supply schemes**
1	Koatmanchuong	Pakang and Warwuot	6 Hand Pumps and Traditional Hand dug wells
2	Teluth	Kuerdiet and Zuogngoal mach	1 Hand Pump and Hand dug wells
3	Ngor	Mhadong and Haat	3 Hand Pumps and Traditional Hand dug Wells
4	Riek	Bhol and Kuermachar	4 Hand Pumps and Traditional Hand dug wells
5	Keach	Tetbollew and Petmachyier	5 Hand Pumps and Traditional Hand dug Wells
6	01	Rotgong and Parish	5 Water Points of Piped Water and 6 Hand Pumps
7	02	Patuak and Melesegna	3 Water Points of Piped Water and 6 Hand Pumps
8	Mutduerkoang	Wunchuiy and Ling-ling	Traditional Hand dug wells and 3 Hand pumps

9	Nip-nip	Orang and Kuerliey	8 Hand Pumps and Traditional Hand dug Wells
10	Kurthogn Chienggach	Thakgok and Kuerjognang	Hand Dug Wells and 4 Hand pumps

Annex 7: Some Analyzed Variables with Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
How much do you pay for water	315	.00	16.00	.6016	1.62362
Number of Jerry cans fetch per day	315	1.00	16.00	2.6952	1.40375
Valid N (listwise)	315				

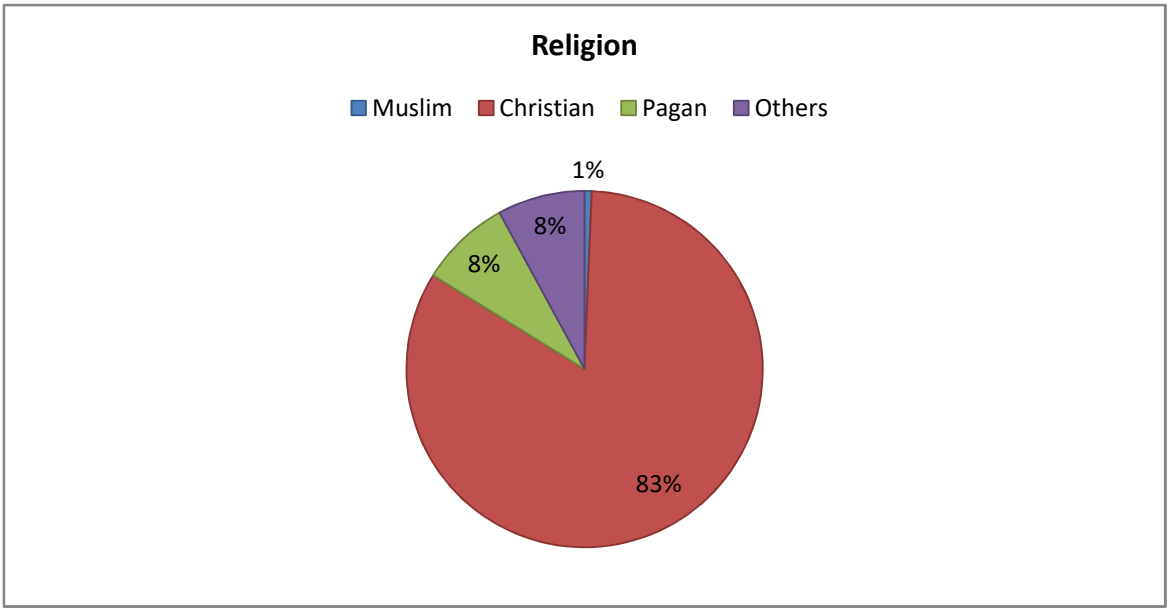
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Family size of respondents	315	2.00	20.00	9.8667	3.62950
Number of Jerry cans fetch per day	315	1.00	16.00	2.6952	1.40375
Valid N (listwise)	315				

Annex 8: General Background Information of Respondents in the Study Area

Sex of the Respondents	**Frequency**	**Percent**
Male	154	48.89%
Female	161	51.11%
Total	315	100%
Age of the Respondents		
15-30 Years old	114	36.19%
31-45 Years old	108	34.29%
46-60 Years old	58	18.41%
Above 60 Years old	35	11.11%
Total	315	100%
Marital Status of the Respondents		
Single	56	17.80%
Married	180	57.10%
Divorced	41	13.00%
Widowed	38	12.10%
Total	315	100%
Educational Level of the Respondents		
Do not read and write	58	18.41%
Primary education	122	38.73%
Secondary education	50	15.87%
Preparatory program	38	12.06%
Higher education	47	14.92%
Total	315	100%

Annex 9: Religion of the Respondents in the Study Area



Annex 10: Socio-Economic Status in the Study Area

Monthly income of the Respondents	Frequency	Percent
Less than 3000 Birr	145	46.03%
3001-6000 Birr	95	30.16%
6001-9000 Birr	55	17.46%
Above 9000 Birr	20	6.35%
Total	315	100%

Annex 11: Some Photographs Taken During Data Collection

Annex 12: Questionnaire for Criteria Weight Calculation

Community Factors										Financial Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Community Factors										Institutional Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Community Factors										Technical Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Community Factors										Environmental Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Financial Factors										Institutional Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Financial Factors										Technical Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Financial Factors										Environmental Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Institutional Factors										Technical Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Institutional Factors									Environmental Factors							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Technical Factors									Environmental Factors							
8	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Annex 13: Consistency Checking on AHP

Criteria Weight	0.0344	0.0736	0.1303	0.5753	0.2645	Weighted Sum Value	Criteria Weights	WSV/CW
	Community Factors	Financial Factors	Institutional Factors	Technical Factors	Environmental Factors			
Community Factors	0.0344	0.02429	0.0261	0.0633	0.0370	0.1851	0.0344	5.3808
Financial Factors	0.1032	0.0736	0.0430	0.0805	0.0873	0.3876	0.0736	5.2663
Institutional Factors	0.172	0.2208	0.1303	0.1151	0.0529	0.6911	0.1303	5.3039
Technical Factors	0.3096	0.5152	0.6515	0.5753	0.7935	2.8451	0.5753	4.9454
Environmental Factors	0.2408	0.2208	0.6515	0.1898	0.2645	1.5674	0.2645	5.9259

Lambda Max = (5.3808+5.2663+5.3039+4.9454+5.9259)/5

Lambda Max = 26.8223/5 = 5.3645

Consistency Index (C.I) = (Lambda Max – n)/(n – 1), where n is the number of compared elements which is 5, i.e =(5.3645-5)/(5-1)=0.0911

Consistency Ratio (C.R) = C.I/R.I where R.I = 1.12

Therefore, C.R = 0.0911/1.12 = 0.0813 < 0.1, it is reasonably consistent.

R.I = Random Index

n	1	2	3	4	5	6	7	8	9	10
R.I	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49